BROOKS HALL

SAN FRANCISCO PUBLIC LIBRARY

VITA SINE LITERIS MORS EST

BOOK NO. ACCESSION

697 Am35g^{8} 313678

NOT TO BE TAKEN FROM THE LIBRARY

Form 37 10M 11-35

SAN FRANCISCO PUBLIC LIBRARY
3 1223 90190 9631

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS GUIDE

1930

[illegible]

[illegible]

[illegible]

[illegible]

VOL. 8

[illegible]

American Society of Heating and Ventilating Engineers
[illegible]

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS GUIDE

1930

AN INSTRUMENT OF SERVICE PREPARED FOR THE PROFESSION—AND CONTAINING REFERENCE DATA ON THE DESIGN AND SPECIFICATION OF HEATING AND VENTILATING SYSTEMS—BASED ON THE TRANSACTIONS—THE INVESTIGATIONS OF THE RESEARCH LABORATORY—AND THE PRACTICE OF THE MEMBERS AND FRIENDS OF THE SOCIETY

TOGETHER WITH A

MANUFACTURERS' CATALOG DATA SECTION CONTAINING ESSENTIAL AND RELIABLE INFORMATION CONCERNING MODERN EQUIPMENT

ALSO

THE ROLL OF MEMBERSHIP OF THE SOCIETY

WITH

COMPLETE INDEXES OF TECHNICAL AND CATALOG DATA

Vol. 8

$5.00 PER COPY

PUBLISHED ANNUALLY BY

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

29 WEST 39TH STREET ∴ NEW YORK

Copyright, 1929
by
ican Society of Heating and Ventilating Engineers

and by it
Dedicated
To the Advancement of
The Profession
and
Its Allied Industries

x697
Am35γ 8
313678

und by
Company
MARYLAND

Contents

Page

INDEX TO TECHNICAL DATA .... v-xii

EDITORIAL ACKNOWLEDGMENT xiii

CODE OF ETHICS FOR ENGINEERS xiv

INTRODUCTION *to* AND SUGGESTIONS *for* THE EFFECTIVE USE OF THE GUIDE 1

CHAPTER 1. Codes and Standards 3

CHAPTER 2. Heat Losses from Buildings 5

CHAPTER 3. Standards of Ventilation 85

CHAPTER 4. Systems of Ventilation 109

CHAPTER 5. Heating with Warm Air Furnaces by Gravity 127

CHAPTER 6. Heating with Warm Air Furnaces by Fan Pressure 149

CHAPTER 7. Air Conditioning 159

CHAPTER 8. Air Cleaners 181

CHAPTER 9. Unit Heaters and Air-Conditioners 189

CHAPTER 10. Heating by Coal 203

CHAPTER 11. Heating by Gas 217

CHAPTER 12. Heating by Oil 231

CHAPTER 13. Heating by Electricity 247

CHAPTER 14. Chimneys 251

CHAPTER 15. Boilers for Steam and Hot Water Heating 263

CHAPTER 16. Conductors and Convectors for Heating by Steam and by Hot Water 275

CHAPTER 17. Automatic Heat Control 287

CHAPTER 18. Pipe and Fittings 299

CHAPTER 19. Pumps and Traps 309

CHAPTER 20. Piping for Steam Heating Systems 331

CHAPTER 21. Piping for Hot Water Heating Systems 367

CHAPTER 22. Piping and Equipment for Laundry, Kitchen and Hospital Service 387

CHAPTER 23. Water Supply Piping for Buildings 397

CHAPTER 24. Heat Insulation for Pipes and Surfaces 405

CHAPTER 25. District Heating 417

CHAPTER 26. Selection of Fans and Motive Power 431

CHAPTER 27. Air Ducts 445

CHAPTER 28. Pneumatic Exhaust Systems 457

CHAPTER 29. Drying by Evaporation 469

CHAPTER 30. Ozone and Ventilation 491

CHAPTER 31. Special Heating and Ventilating Applications 499

CHAPTER 32. Summary of Important Specification Items 505

CHAPTER 33. Physical Properties, Weights, Measures and Tables 513

CHAPTER 34. Symbols and Abbreviations 523

CATALOG DATA SECTION 534–874

INDEX TO MODERN EQUIPMENT 875

INDEX TO ADVERTISERS IN CATALOG DATA SECTION 885

ROLL OF MEMBERSHIP 1–54

INDEX TO

TECHNICAL DATA SECTION

(Pages 1–532)

CROSS REFERENCE TO SUBJECTS IN CHAPTERS 1-34 ALPHABETICALLY LISTED

A

Page

- Abbreviations for engineering and scientific terms 523
- Absolute temperature, definition of 514
- Adiabatic drying 472
- Agitator dryers 473
- Air
  - air movement determinations 104
  - chart 105
  - changes 64
  - distribution in ventilation 87, 122, 177
  - frictional resistance in pipes 463
  - gas combustion 218
  - inside temperatures 6
  - motion 86
  - outside temperatures 9
  - properties of dry air, table of 520
  - properties of saturated air, table of 518
  - purity 87
  - required for combustion 205
  - secondary 210, 219
  - spaces 18
  - supply for ventilation 85
  - temperature entering unit heaters 191
  - temperature for ventilation 86
  - temperature leaving unit heaters 191
  - turbine ventilators 115
  - velocities of dry air at various temperatures and pressures, tables of 446, 517, 518
  - velocity required for exhaust systems 459
  - volume handled through collecting hoods 462
- Air cleaners
  - dust removal efficiency 187
  - dusts 181
  - filters 184
  - fumes 181
  - rating 181
  - smokes 181
  - testing code 188
  - washers 182
- Air conditioners, Unit 196
- Air conditioning
  - air distribution 122, 177
  - dew-point 162
  - equipment 170
  - evaporation, temperature of 162
  - efficiency of employees 160

Page

  - fundamental principles 161
  - human comfort 161
  - humidity controlling devices 179
  - hygroscopic materials 169
  - industrial processes 159
  - libraries 503
  - relation of dew-point to relative humidity 165
  - rate of evaporation 166
  - systems of air distribution 177
  - systems of dehumidification 176
  - systems of humidification 170
- Air cooling 169, 176
- Air current dryers 473
- Air distribution 122, 177
- Air ducts
  - exhaust systems 452
  - friction losses 447, 449
  - fundamentals of design 445
  - installation 452
  - insulation 456
  - proportioning the size 449
- Air filters
  - automatic viscous 187
  - dry air 187
  - unit viscous 185
  - viscous 184
- Air turbine ventilators 115
- Air velocity in exhaust systems 469
- Air washers
  - control of temperature and humidity 182
  - humidifying efficiency 182
  - steam requirements 183
  - types 182
- Alloy metal pipe 301
- Alternating receiver traps 330
- Anemometers 103
- Anthracite coal 203, 206, 216
- Apartment house
  - water requirements for 402
  - water supply mains 399
  - water supply risers 399
- Application of ozone 496
- Areas of circles, table of 519

Page

- Arrangement
  - heaters for fan-pressure warm-air systems 154
  - unit heaters 192
  - direct-fired unit heaters 195
  - discharge of unit heaters, direction and location of 192
  - rating unit heaters 191
- Automatic heat control
  - bath and shower control 298
  - domestic hot water heating 297
  - factory heating 294
  - gas fuel 230
  - greenhouse heating 296
  - manufacturing 298
  - office heating 292
  - oil fuel 238
  - residence heating 289
  - school and church heating 291
  - swimming pool heating 296
  - theater heating 295
  - types of thermostats 288
  - unit heaters 193
  - unit ventilating machines 201
- Automatic viscous air filters 187
- Auxiliary apparatus for industrial oil burners 245
- Available draft 253

B

- Bacteria determinations 103
- Barn ventilation 501
- Bath and shower temperature control 298
- Bituminous coal 204, 207, 216
- Blast heater connections 366
- Blowers, centrifugal 433
- Boilers
  - cross-connecting coal and gas 230
  - cleaning 269, 274
  - care of idle boilers 274
  - domestic heating for oil 240
  - flues, cleaning of 274
  - gas 227
  - hand fired 211
  - hot water supply 273
  - industrial heating for oil 244
  - installation 268
  - protection 271
  - pipe connections, to 271
  - ratings 266
  - selection of coal 264
  - selection of gas 228
  - smoke breeching and chimney connections 271
  - space allowance 268
  - troubles 272
  - types 267
  - water line 269
- British thermal unit, definition of 513
- Burner installation, oil 240

C

- Cabinet convectors 286
- Cabinet dryers 474
- Calculations
  - draft 251
  - exhaust systems 464
  - heat losses 5, 31, 75, 129
  - infiltration 67
- Calorie, definition of 513
- Calorific values
  - coal 204
  - gas 217
  - oil 232
- Conversion burners for gas 224
- Capacity
  - boiler capacity of unit heaters 193
  - hot water heating pipes 377, 378
  - ozonizers 496

Page

  - pumps 309, 313
  - return mains for district heating 424
  - steam pipes 341, 342, 350
  - supply mains for district heating 424
  - traps 327
  - unit heaters 191
  - water supply piping 397
- Capillary moisture in drying 476
- Carbon dioxide (CO_2) determinations 102
- Cast metal pipe 301
- Central heating
  - capacity of returns with various grades 424
  - capacity of supply mains 424
  - conduits 427
  - expansion of pipe 419
  - pipe-line expansion 419
  - pipe tunnels 429
  - service connection methods 417
  - steam supply, control of 417
  - steam per square foot of radiation 429
  - supply mains, capacity of 424
- Centrifugal fans and blowers 433
- Chemical reactions of ozone 492
- Chimneys
  - construction of 261
  - design of 242, 256
  - draft 251
  - gas appliances 258
  - horsepower rating 254
  - oil fuel 256
  - smoke test 262
- Church building temperature control 291
- Circles, areas and circumferences of 519
- Circulation control in drying 480
- Circumferences of circles, table of 519
- Coal
  - combustion 205
  - composition 203
  - draft required for burning 209
  - hand firing 210
  - heating costs with 216
  - heat values 204
  - kinds 203
  - mechanical stoker firing 212
  - secondary air 210
  - storage space 215
- Codes
  - air cleaners 188
  - boiler testing 266
  - heating and ventilation, general 3
  - installing warm air furnaces, for 131
  - radiator 277
  - warm air gravity furnaces, installation of 141
- Coefficients of transmission
  - by computation 14, 20, 35
  - by test 12
  - tables of 35
- Coke 205, 209
- Cold surfaces, insulation for 79, 408
- Cold water
  - branch supply pipe sizes 398
  - risers 398
- Combustion of coal 205
- Comfort charts, how to use 93
- Comfort line 95
- Comfort zone 95
- Compartment dryers 474
- Composition of coal 203
- Concealed convectors 286
- Condensation on pipes, prevention of 409
- Condensation on windows 82
- Condensation, prevention of in buildings 79
- Conductances of materials 19
- Conductivities of materials 19

Page

- Conductors
  - definition of 275
  - heating 279
  - heat emission of pipe coil 284
  - heat transmission of 279
  - pin-type 285
- Connections
  - blast heater 366
  - gas appliances for kitchens 391
  - heater 363
  - Hartford return 360
  - mains 360
  - pipe coil 366
  - piping 360
  - return connections for kitchens 390
  - steam supply for kitchens 390
  - sterilizers 395
  - unit heater 195, 366
  - vapor and vacuum system 361
  - water connections for kitchens 390
- Constant temperature drying 472
- Construction of dryers 489
- Continuous operation drying 470
- Continuous type ventilators 116
- Control
  - dew-point 174
  - drying operation 480
  - gas-fired boilers 230
  - humidity 179
  - motive power for fans 439, 441
  - oil-fired heating system 238
  - temperature 287
- Convectors
  - blast 286
  - cabinet 286
  - cast iron gravity indirect 283
  - concealed 286
  - definition of 276
  - factors affecting heat emission 277
  - indirect gravity 286
  - unit of heat output 276
- Conveyor pipes for dust 467
- Conveyor pipes for exhaust systems 467
- Cooling units 198
- Corrosion, pipe 301
- Costs, heating
  - coal 216
  - electricity 247
  - gas 219
  - oil 231
- Cross-connecting coal and gas boilers 230
- Cross-sections for materials 525, 526
- Cylinder or can dryers 473

D

- Dairy barn ventilation 501
- Definitions
  - British thermal unit 513
  - calorie 513
  - conductors 275
  - convectors 276
  - dew-point 262
  - differential vacuum heating system 331
  - down-feed systems 332
  - dust 181
  - fumes 181
  - gravity heating systems 331
  - pumps 322, 325
  - smokes 181
  - steam heating systems 331
  - two-pipe heating systems 332
  - up-feed systems 332
  - vacuum heating systems 331
  - vapor heating systems 331
  - wet returns 332
- Degree-days 220
- Dehumidification, systems of 176

Page

- Density of liquids, table of 521
- Design
  - air ducts 445, 449
  - chimneys 242, 256
  - dryers 484
  - fan pressure warm air systems 151
  - hoods for exhaust systems 467
  - ventilating systems 87, 123
  - warm air furnaces, fan pressure 151
  - warm air furnaces, gravity 128
- Dew-point
  - control 174
  - definition of 162
  - relation of relative humidity to 165
- Differential vacuum heating system, definition of 331
- Direct gravity ventilating systems 120
- Direct-indirect gravity ventilating systems 120
- Disc and propeller fans 432
- Domestic heating by electricity 248
- Domestic heating by gas 158, 220
- Domestic heating by oil
  - burner installations 240
  - burners, types of 236
  - chimney design 242, 256
  - fuel oils 235
  - hot water heating 241
  - ignition, systems of 237
  - methods of operation 235
  - oil storage tanks 242
  - safety controls 239
  - temperature control 238
- Down-draft furnaces 212
- Down-feed systems, definition of 332
- Draft
  - available 253
  - measurement 251
  - natural 251
  - required for burning coal 207, 209
  - theoretical 252
- Drafting symbols for heating and ventilation 523, 524, 525
- Drum dryers 473
- Dry air
  - properties of 520
  - velocities at various temperatures and pressures 446, 517, 518
- Dry air filters 187
- Dryers
  - air current 473
  - arrangement and construction 489
  - cylinder or can 473
  - design 484
  - drum dryers 473
  - experimental technique 489
  - loft, compartment, cabinet or room 474
  - mechanical contact 473
  - methods of calculation 484
  - operating 480
  - pan or agitator 473
  - rotary 473
  - rule of thumb estimating 489
  - spray 473
  - types of 473
  - tunnel 474
- Drying
  - adiabatic drying 472
  - continuous and intermittent operation 470
  - constant temperature drying 472
  - constant rate period 475
  - cycle 476
  - capillary and hygroscopic moisture 476
  - control of drying operation 480
  - circulation control 480
  - equilibrium moisture content 479
  - falling rate period 475
  - fiber saturation point 477

Page

  - high-temperature drying 471
  - heat and humidity control 481
  - internal moisture gradient 479
  - low-temperature drying 471
  - methods 469
  - mechanism of drying 474
  - moisture content calculations 482
  - omissions in drying cycle 476
  - radiant heat 470
  - removal of free water 477
  - selection of fans 437
  - stages of moisture diffusion 474
  - vacuum drying 472
  - ventilation phase 487
- Ducts
  - exhaust systems 452
  - friction in elbows 449
  - friction losses 447
  - fundamentals of design 445
  - installation 452
  - insulation 456
  - proportioning 449
  - warm air furnaces, for 134
- Dust
  - collectors 466
  - conveyor pipes 467
  - definition of 181
  - determinations 103
  - exhaust systems 457
  - fans for collecting and conveying 438
  - removal efficiency of air cleaners 187

E

- Economic thickness of pipe insulation 416
- Effective temperature 85, 93
- Efficiency of employees, air conditioning for 160
- Ejector type ventilators 115
- Electric motors and controls for mechanical stokers 215
- Electricity
  - heating costs 247, 248
  - heat equivalents of 249
  - hot water heaters 249
  - hot water heating system 249
  - storage system 248
  - warm air heating system 249
- Enclosures, effect of on heat emission of radiators 280
- Equilibrium moisture content in drying 479
- Evaporation
  - rate of 166
  - temperature of 162, 163
- Exhaust systems, pneumatic
  - air velocity 459
  - calculations 464
  - conveyor pipes 467
  - design of hoods 467
  - maintenance 468
  - requirements of efficient operation 458
  - types 457
  - typical layout 464
- Expansion and contraction of piping 306, 419
- Expansion of solids, table of 518
- Experimental technique in design of dryers 489

F

- Factory temperature control 294
- Falling rate period in drying 475
- Fans
  - arrangement of drive 443
  - centrifugal 433
  - characteristic curves 432
  - designation of 443
  - disc and propeller 432
  - drying 437
  - dust collecting and conveying 438

Page

  - full backward curve multiblade 435
  - motive power 439
  - selection 436
  - ventilation 436
- Ferrous pipe 299
- Fiber saturation point in drying 477
- Filters, air 184
- Fittings, insulation for 416
- Flow of steam in pipes 334
- Flues, cleaning of 274
- Forced circulation
  - hot water heating 379
  - warm air heating 148
- Forward curved multiblade fans 434
- Friction in duct elbows 449
- Friction losses in air ducts 447, 449
- Fuel oils for domestic heating 235
- Fuel saving with insulation 31
- Full backward curve multiblade fans 435
- Fumes, definition of 181
- Furnaces, warm air fan pressure
  - arrangement of heaters 154
  - description of 149
  - design of 151
  - fuels 150
  - gas-fired residence system 157
  - large buildings 153
  - rating 150
  - selection of heaters 153
  - small buildings 156
  - specifications for residence system 158
- Furnaces, warm air gravity
  - calculating heat losses 129
  - code for installing 141
  - design of 128
  - ducts 134
  - forced or booster circulation 148
  - grilles 134
  - leader pipe sizes 129
  - register area 134
  - recirculating ducts and grilles 134
  - size of 136
  - wall stacks 132

G

- Gas
  - air for combustion 218
  - boilers 227, 228
  - chimneys 258
  - cross-connecting boilers 230
  - control features 230
  - conversion burners 224
  - calorific value 217
  - fuel costs 219
  - insulation and weatherstripping 224
  - requirements of buildings 220
  - ratings for appliances 229
  - selection of boilers 228
  - space heaters 228
  - table of properties 522
  - warm air furnaces 227
- Generators, ozone 494
- Gravity circulation
  - hot water heating 367
  - warm air heating 127
- Gravity steam-heating systems
  - definition 331
  - one-pipe 341
  - one-pipe down feed 343
  - two-pipe 343
  - vapor 345
- Gravity ventilating systems 119
- Greenhouse heating 499
- Greenhouse temperature control 296
- Grilles for warm air furnaces 134

H Page

- Hand fired boilers 211
- Hartford return connections 360
- Heaters
  - factors affecting heat emission 277
  - selection of 285
  - types of 281
- Heat emission
  - pipe coils 284
  - radiators 277
- Heat exchangers 502
- Heat losses
  - air spaces 18
  - areas where transmission losses occur 31
  - air changes 64
  - bare fittings 416
  - bare pipe 405
  - boiler feed pumps 309
  - by infiltration 60
  - by transmission 12
  - calculating 5, 31
  - calking of frames 66
  - computations, examples of 75
  - condensation, prevention of in buildings 79
  - condensation on windows 82
  - conductivities 19
  - conductances 19
  - effect of humidification 6
  - fuel saving 31
  - high ceilings 7
  - hot-box test 12
  - hot-plate test 19
  - heat required for infiltration 60
  - heat sources 73
  - heat loss computations, examples of 75
  - infiltration through cracks 61
  - infiltration through materials 60
  - infiltration, calculations for 67
  - infiltration due to temperature difference 68
  - inside temperatures 6
  - insulation, economic value of 31
  - metal sash windows, double hung 65
  - metal sash windows, rolled section 65
  - Nicholls heat meter 13
  - outside temperatures 9
  - radiation saving 33
  - Reitchels' formula 9
  - steel windows 65, 66
  - storm windows 66
  - stratification of air 7
  - surface coefficients 18
  - symbols and definitions 14
  - temperature at proper level 7
  - transmission coefficients by test 12
  - transmission coefficients by computation 14, 20, 35
  - wood sash windows, double-hung 62
  - weatherstripping, economic value of 70
  - wind movement 70
- Heat output of radiators, unit of 276
- Heating costs
  - coal 216
  - electricity 247
  - gas 219
  - oil 231
- High ceilings, temperature of air at 7
- High-pressure traps 328
- High-temperature drying 471
- Hill Dust Counter 103
- Horsepower rating of chimneys 254
- Horizontal feed stokers 214
- Hospitals
  - cost of operating sterilizers 393
  - open and closed sterilizers 394
  - selection of sterilizers 393
  - water and vent connections 395
  - water requirements for 402, 403

Page

- Hotels
  - water requirements for 402
- Hot-box test 12
- Hot-plate test 19
- Hot-water heating systems
  - comparison of gravity and forced systems 381
  - determining pipe sizes 372
  - expansion tank, location of 370, 385
  - forced circulation 379
  - gravity flow 367
  - maximum water temperature 369
  - optimum velocity of water 385
  - piping for 367
  - supply boilers 273
  - temperature drop through radiation 371
- Hot water temperature control 297
- Human comfort, air conditioning for 161
- Humidification, effect of on inside temperature 6
  - systems 170
- Humidifying efficiency of air washers 182
- Humidity, effect of on heat emission 279
- Hygroscopic
  - materials 169
  - moisture 476

I

- Idle boilers, care of 274
- Ignition systems for oil burners 237
- Impinger 103
- Induction type ventilators 115
- Industrial heating by oil
  - auxiliary apparatus 245
  - burners 242
  - draft for industrial burners 244
  - furnace 244
- Industrial processes, air conditioning for 159
- Infiltration
  - calculations for 67
  - due to temperature difference 68
  - heat required for 60
  - through cracks 61
  - through materials 60
- Installation of air ducts 452
  - of boilers 268
  - of oil burners 240
- Insulation
  - cold surfaces 79, 408
  - conductivities of building insulation 19, 23
  - conductivities of pipe covering 411
  - duct 456
  - economic thickness of pipe insulation 416
  - economic value of building insulation 31
  - electrically heated buildings 247
  - fittings 416
  - gas heated buildings 224
  - hot water lines 406
  - pipe covering factors 411
  - prevention of condensation on pipes 409
  - steam lines 406
  - thicknesses of pipe insulation used 411
- Intermittent operation drying 470
- Internal moisture gradient in drying 479

K

- Kata thermometer 104
- Kitchens
  - connections for steam supply 390
  - electricity required for cooking 391
  - equipment required 390
  - gas appliances, connections to 391
  - return connections 391
  - steam consumption 390
  - steam pressure limits 391
  - water connections 390
  - water consumption 390
- Konimeter 103

L Page

- Lacquer spray booths, ventilation of 503
- Laundries
  - arrangement of equipment 389
  - equipment required 387
  - importance of soft water 389
  - water, steam and power required 388
- Leader pipe sizes for warm air furnaces 129
- Libraries, air conditioning of 503
- Lignite 205
- Lineal expansion of solids, table of 518
- Loft dryers 474
- Low-pressure traps 329
- Low-temperature drying 471

M

- Mains
  - connections to 360
  - return 331
  - supply 331
- Manufacturing processes, temperature control of 298
- Maximum water temperature in hot water heating systems 369
- Measurement of draft 251
- Measures 513
- Mechanical contact dryers 473
- Mechanical stokers
  - electric motors and controls 214
  - selection 215
  - types 212
- Mechanical ventilating systems 121
- Mechanism of drying 474
- Metal sash windows
  - double hung 65
  - rolled section 65
- Metric units, table of 521
- Micro-organisms, effect of ozone on 492
- Moisture diffusion in drying 474
- Motive power for fans
  - control 439, 441
  - electric motors 439, 440

N

- Natural draft 251
- Natural ventilating systems 109
- Nicholls heat meter 13
- Non-ferrous pipe 304

O

- Odoriferous substances, effect of ozone on 493
- Office buildings, water requirements for 402
- Office temperature control 292
- Oil
  - combustion sounds 234
  - domestic heating 235
  - heat content 233
  - heating costs 231
  - industrial heating 242
  - mechanical sounds 234
  - storage tanks 242
  - traps 350
- Omissions in drying cycle 476
- One-pipe heating systems, steam 341, 343
- Optimum velocity of water in hot water heating systems 385
- Overfeed stoker 212
- Ozone
  - application in ventilation 491
  - chemical reactions 492
  - effect on micro-organisms 492
  - generators 494
  - industrial ventilation 496
  - method of application 496
  - odoriferous substances 493
  - physical characteristics 491
  - proper concentration 495
  - quantitative analysis 495
  - ventilation 491

Page

- Ozonizers
  - capacity 496
  - commercial 494

P

- Paddle wheel type fan 434
- Paint, effect of on heat emission of radiators 279
- Pan dryers 473
- Partial backward curve multiblade fans 434
- Physical characteristics of ozone 491
- Physical units 513
- Pin type radiators 285
- Pipe coil connections 366
- Pipe coil radiators 283
- Pipe connection to boilers 271
- Pipe covering, conductivities of 411
- Pipe insulation
  - cold surfaces 408
  - economic thickness of 416
  - effect of air velocity on surface losses 412
  - heat losses through bare fittings 416
  - heat losses through bare pipe 405
  - hot water lines 406
  - steam lines 406
- Pipe sizes
  - hot water heating systems 372
  - steam heating systems 335
  - water supply for buildings 397
- Pipe tunnels 429
- Piping
  - alloy metal 301
  - arrangement for hot water systems 371
  - cast metal 301
  - connections for steam heating systems 360, 366
  - corrosion 301
  - expansion and contraction 306, 419
  - ferrous 299
  - hot water systems 367
  - non-ferrous 304
  - protective coatings 301
  - standards 306
  - steam heating systems 331
  - testing 306
  - water supply for buildings 397
  - welding 301
  - wrought iron 301
- Pitot tubes 103
- Pressing rooms in clothing factories, ventilation of 503
- Properties
  - dry air, table of 520
  - gases, table of 522
  - saturated air, table of 518
  - saturated steam, table of 515, 516
- Protective coatings for pipe 301
- Protection of boilers 271
- Pulverizers, fuel 215
- Pumps
  - boiler feed 309
  - condensation 310
  - definitions 322, 325
  - equipment 324
  - fittings 324
  - installation data 326
  - specifications for 321
  - vacuum heating 313

R

- Radiant heat for drying 470
- Radiation 286
  - equivalent 331
  - ratio of radiation to volume of space heated 430
  - saving due to insulation 33
  - steam per square foot of 429
  - supply of steam to, in district heating 417

ALPHABETICAL INDEX TO TECHNICAL DATA SECTION

Page

- Radiators
  - cast iron 283
  - definition of 275
  - enclosures, effect of 280
  - humidity, effect of 279
  - heat emission 277
  - location 285
  - pin-type 285
  - pipe coil 283
  - paint, effect of 279
  - selection 285
  - types 281
  - unit of heat output 276
- Rating
  - air cleaners 181
  - boilers 266
  - fan-pressure warm air furnaces 150
  - gas appliances 229
  - insulations 19
  - unit heaters 191
- Recirculating ducts and grilles for warm air furnaces 134
- Register area for warm air furnaces 134
- Reitchels formula 9
- Relation between velocity, acceleration and time passed over 514
- Relative humidity
  - control of in drying 481
  - controlling devices 179
  - control of in air washers 182
  - control system 174
  - determinations of 102
  - effect of on heat emission of radiators 277
  - relation of dew-point to 165
- Removal of free water in drying 477
- Residence temperature control 289
- Risers
  - downfeed one-pipe 332
  - one-pipe supply 332
  - two-pipe supply 332
- Roof ventilators 114, 115, 116, 117, 118
- Room dryers 474
- Rotary dryers 473
- Rotary ventilators 115, 117
- Rule of thumb estimate, dryers 489

S

- Safety controls for oil burners 239
- School building temperature control 291
- Selection
  - boilers 263
  - fan pressure heaters 153
  - fans 436
  - gas boilers 228
  - heaters 285
  - heaters for fan-pressure warm air systems 153
  - hot water supply boilers 273
  - radiators 285
  - roof ventilators 117
  - sterilizers 393
  - stokers 215
- Siphon ventilators 115
- Smokeless arch 211
- Smokes, definition of 181
- Smoke test of chimneys 262
- Space allowance for boilers 268
- Space heaters, gas 228
- Specifications
  - description of work 508
  - general conditions 505
  - instructions to bidders 505
  - items, summary of 505
- Specific heat of solids and liquids, table of 521
- Spray dryers 473
- Standards
  - heating and ventilation, for 3
  - pipe, for 306

Page

- Stationary ventilators 115, 117
- Steam heating systems
  - definitions 331
  - pipe sizes 335
  - piping connections 360
  - steam distribution 332
- Steam requirements of air washers 183
- Steam required per square foot of radiation 429
- Sterilizers for hospitals
  - cost of operating 393
  - open and closed 394
  - selection of 393
  - waste and vent connections 395
- Stokers
  - electric motors and controls 214
  - horizontal feed 214
  - over-feed 212
  - selection 215
  - types 212
  - underfeed 213
- Storage tanks, oil 242
- Storm windows 66
- Stratification of air 7
- Surface coefficients 18
- Swimming pool temperature control 296
- Symbols
  - drawing 523, 524, 525, 526
  - force, weight, work, power 527
  - general 527
  - heat and thermodynamics 527
  - heat transmission 529
  - materials 525
  - properties 527
  - thermodynamics 528
- Synthetic air chart 105

T

- Temperature
  - air entering unit heaters 191
  - air leaving unit heaters 191
  - at proper level 7
  - constant-temperature drying 472
  - control of oil-fired heating system 238
  - determinations 101
  - drop through radiation 371
  - effective temperature 85, 93
  - high-temperature drying 471
  - inside temperatures 6
  - low-temperature drying 471
  - maximum water temperature for hot water systems 369
  - of evaporation 162
  - outside temperatures 9
  - temperature regulation 287
- Testing
  - air cleaner code 188
  - boiler code No. 3 266
  - methods and instruments 101
  - pipe 306
- Theoretical draft 252
- Theaters, temperature control of 295
- Thermostats, types of 288
- Thicknesses of pipe insulation 411
- Thread cutting 301
- Transmission coefficients
  - by computation 14, 20, 35
  - by test 12
  - tables of 35
- Traps
  - air 330
  - alternating receiver 330
  - capacity 327
  - high pressure 328
  - lifting 329
  - low pressure 329
  - oil 330
- Tunnel dryers 474

Page

- Tunnels, pipe 429
- Two-pipe gravity steam heating systems 343
- Two-pipe steam heating systems, definition of 332
- Types
  - air washers 182
  - boilers 267
  - exhaust systems 457
  - heaters 281
  - radiators 281
  - stokers 212
  - thermostats 288
  - unit heaters 190

U

- Underfeed stoker 213
- Unit heaters
  - arrangement 192
  - automatic control 193
  - boiler capacity 193
  - connections 195, 366
  - direct fired 195
  - discharge, direction and location of 192
  - functions of 189
  - heating mediums 190
  - procedure for determining heat to be supplied 190
  - quietness of operation 198
  - ratings and capacities 191
  - temperature of air entering 191
  - temperature of air leaving 191
  - types 190
- Unit of heat output of radiators 276
- Unit type roof ventilators 118
- Unit viscous air filters 185
- Up-draft furnaces 211
- Up-feed systems, definition of 332

V

- Vacuum drying 487
- Vacuum heating systems
  - condensation pump 349
  - definitions of 331
  - piping connections 361
- Vapor heating systems 345
  - definitions of 331
  - gravity 345
  - piping connections 361
- Ventilating machines, unit
  - air intake, location of 200
  - automatic heat control 201
  - blast system 200
  - essential parts 199
  - location of 200
  - pneumatic damper control 201
  - split system 200
  - vent openings 202
- Ventilating systems
  - blast 200
  - central supply mechanical 121
  - design 123
  - direct-indirect gravity 120
  - exhaust 122
  - gravity 119
  - indirect gravity 120
  - mechanical 121
  - natural 109
  - split 199
  - unit supply mechanical 121
  - vent blast 200, 201
- Ventilation
  - air supply for 85
  - air temperature 86
  - air motion 86
  - air purity 86
  - air distribution 87, 122, 177
  - anemometers 103
  - air movement determinations 104
  - air chart 105
  - bacteria determinations 103
  - carbon dioxide (CO_2) determinations 102
  - cold storage warehouses 502
  - conditioning air for human comfort 98

Page

  - comfort charts, how to use 93
  - comfort line 95
  - comfort zone 95
  - dairy barn 501
  - design 87
  - dust determinations 103
  - effective temperature 85
  - effective temperature, definition of 93
  - general requirements of 85
  - heat from occupants, lights, etc. 87
  - heat dissipated by atmosphere from human body 95
  - Hill dust counter 103
  - human comfort, conditioning air for 98
  - human comfort, how temperature, humidity and air motion affect 89
  - human comfort, how relative humidity affects 101
  - humidity determinations 102
  - impinger 103
  - injurious substances 86
  - Kata thermometer 104
  - Konimeter 103
  - lacquer spray booths 503
  - odors 87
  - Pitot tubes 103
  - pressing rooms 503
  - psychological and physiological reactions 89
  - relative humidity, affect of on human comfort 101
  - relative humidity 86
  - recirculation 88
  - selection of fans 436
  - synthetic air chart 105
  - testing methods and instruments 101
  - temperature determinations 101
  - zoning 502
- Ventilators
  - air-turbine 115
  - continuous type 116
  - ejector type 115
  - induction 115
  - roof 114, 115, 116, 117, 118
  - rotary 115, 117
  - siphon 115
  - selection of roof 117
  - stationary 115, 117
  - unit type roof 118
- Viscous air filters 184

W

- Wall stacks for warm air furnaces 132
- Washers, air 182
- Water line of boilers 269
- Water, removal of in drying 477
- Water supply
  - apartment house supply mains 399
  - apartment house supply risers 399
  - cold water branch supply sizes 398
  - cold water risers 398
  - flow of water for various pressure drops 400
  - formula 397
  - hot water 402, 404
  - mains for apartment houses 389
  - piping 398
  - pressure required for various heights 400
  - requirements for apartment buildings 402
  - requirements for hotels 402
  - requirements for hospitals 402, 403
  - requirements for office buildings 402
  - risers for apartment houses 399
  - tank located on roof 403
- Weatherstrips, economic value of 70
- Weights of materials, table of 518
- Welding, pipe 301
- Wet returns, definition of 332
- Wrought iron pipe 301
- Wind movement, affect of on heat requirements 70
- Wood sash windows, double hung 62

Z

- Zoning of heating and ventilation 502

EDITORIAL ACKNOWLEDGMENT

THE Technical Data Section of THE GUIDE 1930 is indicative of the most modern engineering practice and it comprehensively covers the current knowledge on heating and ventilation compiled, condensed and revised from all available sources.

These data have been contributed freely by the foremost engineers of the United States. In no other way, save through the medium of this Society,—unfettered by commercialism or self-interest,—could the liberal cooperation of these men have been obtained. THE GUIDE acknowledges the loyalty and cooperation of the men who have labored so generously to the end that its text pages shall serve usefully to advance the interests of the profession.

The following members of the Society and their friends have contributed to THE GUIDE 1930 without compensation, except that which comes from generous public service:

R. L. BEERS
R. G. BIRKHOLZ
D. R. BREWSTER
R. M. CONNOR
A. A. CRIQUI
C. H. FLINK
DONALD FRENCH
W. GARDNER, JR.
F. E. GIESECKE
F. E. HARTMAN
J. M. HARTMAN
J. J. HAYES
R. H. HEILMAN
J. D. HOFFMAN
J. C. HORNUNG
F. C. HOUGHTEN
A. M. HOUSER
J. H. KITCHEN
W. K. LEWIS
E. C. LLOYD
G. W. MARTIN
J. H. MCILVAINE
H. C. MURPHY
A. J. NESBITT
H. M. NICHOLS
S. I. ROTTMAYER
T. K. SHERWOOD
H. F. TAPP
M. C. W. TOMLINSON
F. W. WANDLESS
PERRY WEST

The debt of the profession, its allied industries and the public at large who will receive the benefits resulting from the untiring work of these contributors, is hereby acknowledged.

GUIDE PUBLICATION COMMITTEE

S. R. LEWIS, *Chairman*,

C. V. HAYNES W. H. CARRIER

J. F. MCINTIRE
Vice-Chairmen

P. D. CLOSE, *Technical Secretary*

CODE *of* ETHICS *for* ENGINEERS

ENGINEERING work has become an increasingly important factor in the progress of civilization and in the welfare of the community. The engineering profession is held responsible for the planning, construction and operation of such work and is entitled to the position and authority which will enable it to discharge this responsibility and to render effective service to humanity.

That the dignity of their chosen profession may be maintained, it is the duty of all engineers to conduct themselves according to the principles of the following Code of Ethics:

1—The engineer will carry on his professional work in a spirit of fairness to employees and contractors, fidelity to clients and employers, loyalty to his country and devotion to high ideals of courtesy and personal honor.

2—He will refrain from associating himself with or allowing the use of his name by an enterprise of questionable character.

3—He will advertise only in a dignified manner, being careful to avoid misleading statements.

4—He will regard as confidential any information obtained by him as to the business affairs and technical methods or processes of a client or employer.

5—He will inform a client or employer of any business connections, interests or affiliations which might influence his judgment or impair the disinterested quality of his services.

6—He will refrain from using any improper or questionable methods of soliciting professional work and will decline to pay or to accept commissions for securing such work.

7—He will accept compensation, financial or otherwise, for a particular service, from one source only, except with the full knowledge and consent of all interested parties.

8—He will not use unfair means to win professional advancement or to injure the chances of another engineer to secure and hold employment.

9—He will cooperate in upbuilding the engineering profession by exchanging general information and experience with his fellow engineers and students of engineering and also by contributing to work of engineering societies, schools of applied science and the technical press.

10—He will interest himself in the public welfare in behalf of which he will be ready to apply his special knowledge, skill and training for the use and benefit of mankind.

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS GUIDE

1930

INTRODUCTION *to* AND SUGGESTIONS *for* THE EFFECTIVE USE OF THE GUIDE, 1930

IN this eighth annual edition of THE GUIDE the user will find a vast amount of new and revised data gathered from a variety of sources. They are presented in readily usable form with the hope that an effective service in the advancement of the industry and profession will be rendered.

Truth and service are supreme in the conception of this volume. It is felt that these form the lifeblood of the profession and of all industries allied to the profession. There has been no deviation from the principles upon which THE GUIDE was founded in 1922.

The makeup of THE GUIDE 1930 has been changed radically in the hope that it will make the book easier to use. Several of the older Chapters have been consolidated and an effort has been made to coordinate the various subjects treated in the 34 Chapters.

All of the data have been prepared by carefully selected Engineers, each preeminent in his specialty, and have been summarized and tabulated for ready reference. Several new Chapters appear in this edition of THE GUIDE. All older Chapters have been revised in accordance with current knowledge and practice.

It will be noted that heating and ventilation have been treated together rather than separately, for the reason that they are so related and interdependent that no definite dividing line can be drawn.

The arrangement and indexing of THE GUIDE 1930 have had special study so that the book may be used with maximum effectiveness. A start has been made this year to supplement the Technical Data with Catalog Data in such form that it "continues the story." Many manufacturers have prepared copy which gives specific instructions to amplify the general rules which appear in the text. An endeavor has been made not so much to enlarge the copy as to improve the content and format.

It is recommended that use be made of the Catalog Data to supplement the Text Data on any subject, as it will be found to contain much of the engineering lore on sizes, shapes, capacities, dimensions, space requirements, applications and installations, so useful in the planning, specifying and installation of mechanical equipment. It is also suggested that the notes and explanations (especially those applicable to tables) be studied, for in the interest of brevity and simplicity certain data have been made to serve many purposes by the use of these notes, but at the same time may be susceptible to improper use if not fully understood.

In the Catalog Data section the manufacturer is invited to present the complete story of his products so that the user shall have before him concise and complete information which shall enable him to make the best selection which modern equipment affords.

It has been the policy that the manufacturers' data presented in the Catalog Data section be useful and serviceable,—not a mere collection of claims, high-sounding catch phrases or superlatives, but an informative presentation of helpful information. Those manufacturers whose Catalog Data appear in The Guide, pay for the service rendered to them as effective advertising, and the support and cooperation of these manufacturers constitute an important part of the means whereby the American Society of Heating and Ventilating Engineers is enabled to achieve the publication and wide distribution of The Guide, and to extend its wholly philanthropic services to the general advancement of the profession and its allied industries. Engineering and manufacturing are dependent upon each other and both, jointly, are essential to the general interests of the public.

The 1930 Guide Publication Committee is gratified by the reception accorded the last edition of The Guide, which had 9,300 users, and in appreciation its untiring efforts have been pledged to the work on The Guide 1930 so that a continuation of this recognition of The Guide's usefulness may persist.

More than 10,000 copies of this issue are published and it is presented to the profession and the industry at large with the hope that it will render an unique service as the standard reference work on heating and ventilating.

CHAPTER 1

CODES AND STANDARDS

VARIOUS codes and standards relating to the design, installation, testing, rating or maintenance of materials and equipment used in the heating and ventilation of buildings, have been adopted. Many of these codes and standards were developed and adopted solely by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, whereas others were developed by other organizations and approved by this Society.

The following are the most important of these codes:

CODE OR STANDARD	WHEN ADOPTED OR APPROVED	SPONSORED BY	REFERENCE
Synthetic Air Chart	June, 1917	A.S.H.V.E.	TRANSACTIONS, Vol. XXIII, p. 607.
Standard and Short-Form Heat Balance Codes for Testing Low Pressure Steam Heating Solid Fuel Boilers (Codes 1 & 2)	Revised, June, 1929	A.S.H.V.E.	Pamphlet.
Performance Test Code for Steam Heating Solid Fuel Boilers (Code No. 3).	Edition of June, 1929, by A.S.H.V.E.	*National Boiler and Radiator Manufacturers Association.*	JOURNAL, A.S.H.V.E., August, 1929.
Code of Ethics for Engineers	January, 1922	A.S.H.V.E.	TRANSACTIONS, A.S.H.V.E., Vol. XXVIII, p. 6. (See also p. xiv THE GUIDE, 1930.
Code for Testing Fans	May, 1923	A.S.H.V.E.	TRANSACTIONS, A.S.H.V.E., Vol. XXIX, p. 407.
Warm Air Furnace Code	First Edition 10–1–22 Second Edition 2–1–23 Third Edition 6–1–24 Fourth Edition 5–1–27 Fifth Edition 3–1–28 Sixth Edition 3–1–29	*National Warm Air Heating Assn.*	Chapter 5, THE GUIDE, 1930.

CODE OR STANDARD	WHEN ADOPTED OR APPROVED	SPONSORED BY	REFERENCE
Standard Test Code for Heat Transmission Through Walls.	January, 1925	A.S.H.V.E.	JOURNAL, A.S.H.V.E. Vol. XXXIV, No. 1, January, 1928.
Approval Requirement for Central House Heating Gas Appliances.	1927	*American Gas Association.*	*American Gas Association,* New York City.
Code for Heating and Ventilating Garages.	June, 1929	A.S.H.V.E.	JOURNAL, A.S.H.V.E. May, 1929, p. 63.
Code of Minimum Requirements for the Heating and Ventilation of Buildings.	June, 1925	A.S.H.V.E.	Code of Minimum Requirements for the Heating and Ventilation of Buildings, Edition of 1929.
Pipe Flanges and Fittings.	1927–1929	*American Society Mechanical Engineers.*	*American Standards Association.*
Code for use of Pitot Tube.	January, 1914	A.S.H.V.E.	TRANSACTIONS A.S.H.V.E., Vol. XX, p. 211.
Identification of Piping Systems.	November, 1928	(1) *American Society Mechanical Engineers;* (2) *National Safety Council.*	*American Standards Association,* JOURNAL, A.S.H.V.E., July, 1929.
Pipe Thread	December, 1919	(1) *American Society Mechanical Engineers;* (2) *American Gas Association.*	*American Standards Association.*
Safety Code for Mechanical Refrigeration.	Submitted for formal approval.	*American Society of Refrigeration Engineers.*	*American Standards Association.*
Code for Testing Radiators.	January, 1928	A.S.H.V.E.	TRANSACTIONS, A.S.H.V.E., Vol. XXXIII.

In addition to the foregoing Codes and Standards, others having an important bearing on the heating and ventilation of buildings are under preparation. These include Code for Rating Low-Pressure Heating Boilers; Code for Testing Unit Heaters; Code for Testing Unit Ventilators; Code for Testing Concealed Radiators, and Code for Testing Air Cleaners.

CHAPTER 2

HEAT LOSSES FROM BUILDINGS

Method of Computing Heat Losses; Data on Inside and Outside Temperatures; Heat Losses by Transmission; Conductivities of Building Materials and Insulations; Heat Transmission Coefficients; Heat Losses by Infiltration; Effect of Wind Movement; Examples of Heat Loss Computations; Prevention of Condensation.

INTRODUCTION

MANY important changes and additions have been made to this chapter of THE GUIDE, 1930. Special effort has been made to base the conductivities and conductances of building materials, insulations and air spaces upon the latest and most reliable test data available. The heat transmission tables have been enlarged and rearranged to include many common types of construction, and all the tables have been recomputed, using a new conductance factor for air spaces. A discussion of the economic value of insulation has been added, together with formulae for solving fuel and radiation-saving problems. Data regarding the prevention of condensation on interior building surfaces have been included.

CALCULATING HEAT LOSSES

The procedure to be followed in determining the heat loss from any building can be divided into seven consecutive steps, as follows:

1. Determine on the inside air temperature, at the breathing line, which is to be maintained in the building during the coldest weather. See Table 1, p. 8.

2. Determine on an outside air temperature for design purposes, based on the minimum temperatures recorded in the locality in question, which will provide for all but the most severe conditions. Such conditions as may exist for only a few consecutive hours are readily taken care of by the heat capacity of the building itself. See Table 3, p. 11.

3. Select or compute the heat transmission coefficients for outside walls and glass, also for inside walls, floors, or top-floor ceilings, if these are next to unheated space; include roof if next to heated space. See pages 14 to 30 and Tables 12 to 36.

4. Measure up net outside wall, glass and roof next to heated spaces, as well as any cold walls, floors or ceilings next to unheated space. Such measurements are made from building plans, or from the actual building.

5. Compute the heat transmission losses for each kind of wall, glass, floor, ceiling and roof in the building by multiplying the heat transmission coefficient in each case by the area of the surface in square feet and the temperature difference between the inside and outside air. (See pars. 1 and 2).

6. Select unit values and compute the heat equivalent of the infiltration of cold air taking place around outside doors and windows. These unit values depend on the kind or width of crack and wind velocity and when multiplied by the length of crack and the temperature difference between the inside and outside air, the result expresses the heat required to warm up the cold air leaking into the building per hour. See pages 60 to 73 and Tables 37 to 42.

7. The sum of the heat losses by transmission (par. 5) through the outside wall and glass, as well as through any cold floors, ceilings or roof, and the heat equivalent (par. 6) of the cold air entering by infiltration represents the total heat loss equivalent for any building.

Item 7 represents the heat losses after the building is heated and under stable operating conditions in coldest weather. Additional heat is required for raising the temperature of the air, the building materials and the material contents of the building to standard inside temperature.

The rate at which this additional heat is required depends upon the heat capacity of the structure and its material contents and upon the time in which these are to be heated.

This additional heat may be figured and allowed for as conditions require, but inasmuch as the heating system proportioned for taking care of the heat losses will usually have a capacity about 100 per cent greater than that required for average winter weather, and inasmuch as most buildings may either be continuously heated or more time be allowed for heating-up, during the few minimum temperature days, no allowance is made except in the size of boilers or furnaces.

General Statement on Specifications

In order that no misunderstanding may occur, the specifications for all heating systems or plants shall include a clause covering the following points:

1. The lowest recorded outside temperature in the locality, as reported by the U. S. Weather Bureau for the preceding 10 years.
2. The outside air and inside breathing-line temperatures which were assumed and actually used in making the heat-loss computations.
3. The heating load should be calculated on a temperature not more than 15 deg. above the minimum outside temperature recorded for the locality for the preceding 10 years and at a wind velocity which is the highest recorded in the locality for such temperature (*i.e.*, for a temperature 15 deg. above the minimum) for the locality in which the heating plant is located. Both wind velocity and direction are to be taken from the U. S. Weather Bureau records of 10 years.

INSIDE TEMPERATURES

Winter

The inside air temperature which must be maintained within a building and which should always be stated in the heating specifications, is understood to be the temperature at the breathing line, 5 ft. above the floor and not less than 3 ft. from the outside walls. Inside air temperatures, usually specified, vary in accordance with the use to which the building is to be put and Table 1 presents values which are in conformity with good practice.

Effect of Humidification: In connection with inside temperatures for winter where humidifying means are provided, approximately 1 deg. variation for each 10 per cent variation in relative humidity should be provided. For example: If the relative humidity is raised from a condition of 15 per cent to one of 45 per cent by artificial humidification it is desirable to lower the indoor temperature about 3 deg. as indicated by the Effective Temperature Line on the Comfort Chart. (See Chapter 3, p. 91.) The temperatures given in the table are for normal dry air with dew-points approximately equivalent to outdoor air. A reduction in the temperatures will be required corresponding to the raise of the moisture content by artificial humidification.

Temperature at Proper Level: In making the actual heat-loss computations, however, for the various rooms in a building it is often necessary to modify the temperatures given in Table 1 so that the air temperature at the proper level will be used. By *air temperature at the proper level* is meant, in the case of walls, the air temperature at the mean height between floor and ceiling; in the case of glass, the air temperature at the mean height of the glass; in the case of roof or ceiling, the air temperature at the mean height of the roof or ceiling above the floor of the heated room, and in the case of floors, the air temperature at the floor level. In the case of heated spaces adjacent to unheated spaces, it will usually be sufficient to assume the temperature in such spaces as the mean between the temperature of the inside heated spaces and the outside air temperature, excepting where the combined heat transmission coefficient of the roof and ceiling can be used, in which case the usual inside and outside temperatures should be applied. (See Table 35, pp. 58 and 59 and discussion regarding the use of combined coefficients of pitched roofs, unheated attics and top-floor ceilings on p. 27.)

The air temperature at the mean height between floor and ceiling is the *breathing-line* temperature, Table 1, for rooms not over 10 ft. in height. For rooms above this height, the temperature should be increased according to the difference between the mean height of the vertical wall, glass, roof or ceiling surface, and the height of the breathing line. The amount of the increase per foot of height will depend on the inside breathing-line temperature; the outside temperature; the wall and roof construction, and the type and location of heaters and other factors.

High Ceilings: Research data concerning stratification of air in buildings are lacking, but in general it may be said that where the increase in temperature is due to the natural tendency of the warmer or less dense air to rise, as where a direct radiation system is installed, the temperature of the air at the ceiling increases with the ceiling height. The relation, however, is not a straight-line function, as the amount of increase per foot of height apparently decreases as the height of the ceiling increases, according to present available information.

Furthermore, the temperature of the air at any level in a building such as at the mean height of walls, is not necessarily proportional to the distance from the floor or breathing line, although in general the temperature increases as the height increases. It is the common practice of engineers to allow 2 per cent per foot of height above the breathing line in determining the probable air temperature at any given level for a direct radiation system, and this value is, no doubt, sufficiently accurate in most cases.

With certain types of heating and ventilating systems, which tend to oppose the natural tendency of warm air to rise, the temperature differential between floor and ceiling can be greatly reduced. These include unit heaters, fan-furnace heaters, and the various types of mechanical ventilating systems. The amount of reduction is problematical in certain instances, as it depends upon many factors such as location of heaters,

TABLE 1. INSIDE TEMPERATURES USUALLY SPECIFIED

TYPE OF BUILDING	DEG. FAHR.
SCHOOLS—	
Class Rooms	68
Assembly Rooms	66 – 68
Gymnasiums	55 – 65
Toilets and Baths	70
Wardrobe and Locker Rooms	65 – 68
Kitchens	66
Dining and Lunch Rooms	65 – 68
Playrooms	60 – 65
Natatoriums	75
THEATERS—	
Seating Space	68 – 72
Lounge Rooms	68
Toilets	68
HOSPITALS—	
Private Rooms	70
Private Rooms (surgical)	70 – 80
Operating Rooms	70 – 95
Wards	68
Kitchens and Laundries	66
Toilets	68
Bathrooms	70 – 80
HOTELS—	
Bedrooms and Baths	70
Dining Rooms	70
Kitchens and Laundries	66
Ball Rooms	65 – 68
Toilets and Service Rooms	68
HOMES—	
Where 68 deg. is generally the desirable standard of temperature a guarantee of 70 deg. is customarily exacted.	
STORES	65 – 68
PUBLIC BUILDINGS	68 – 70
WARM AIR BATHS	120
STEAM BATHS	110
FACTORIES AND MACHINE SHOPS	60 – 65
FOUNDRIES AND BOILER SHOPS	50 – 60
PAINT SHOPS	80

TABLE 2. DESIRABLE INDOOR TEMPERATURES IN SUMMER CORRESPONDING TO OUTDOOR TEMPERATURES

DEGREES OUTSIDE	DEGREES INSIDE		
Dry Bulb	Dry Bulb	Wet Bulb	Effective Temperature
95	80.0	65.2	73.4
90	78.0	64.5	72.2
85	76.5	64.0	71.1
80	75.0	63.5	70.2
75	73.5	63.0	69.3
70	72.0	62.5	68.2

air temperature, and direction and velocity of air discharge. In some cases it has been possible to reduce the temperature between the floor and ceiling to a few degrees, whereas, in other cases, the temperature at the ceiling has actually been increased because of improper design, installation or operation of equipment. So much depends upon the factors enumerated, that it is not advisable to allow less than 1 per cent per foot (and usually more) above the breathing line in arriving at the air temperature at any given level for any of these types of heating and ventilating systems, unless the manufacturers are willing to guarantee that the particular type of equipment under consideration will maintain a smaller temperature differential for the specific conditions involved.

Rietschel's Formula: Rietschel states that the average mean temperature t_m never exceeds 1.15 t for the highest ceilings. His formula is:

$$t_m = t\,[\,1. + 0.017\,(h - 10)\,]$$

in which h is the height of the ceiling or outside walls. Substituting $t_m = 1.15\,t$, it is found that $h = 19$ ft., so that for heights over 19 ft. a value of $t_m = 1.15\,t$ may be used.

Temperature at Floor Level: In determining mean air temperatures just above floors which are next to ground or unheated spaces, a temperature 5 deg. lower than the breathing-line temperature may be used, provided the breathing-line temperature is not less than 55 deg. fahr.

Summer

Where buildings are being artificially cooled for human comfort during the summer a different scale of inside temperatures is required and this inside temperature must depend to a large extent upon the variation in outside temperatures. It is manifestly undesirable and impracticable to maintain a temperature of 70 deg. inside when it is 95 deg. outside, nor can it be said that the inside temperature should be as much as 15 deg. below the outside temperature. At 95 deg. outside, and dry air, a temperature somewhat lower than 80 deg. might be desirable. On the other hand with 85 deg. outside a 70-deg. temperature inside would be entirely too cold. In other words, the spread between the inside and outside temperature must be varied as the outside temperature varies.

Table 2 is based on average moisture conditions outside and upon the assumption of relative humidities inside, between 50 and 60 per cent, which is usual in such installations.

OUTSIDE TEMPERATURES

Winter

The outside temperature used in computing the heat loss from a building is seldom taken as the lowest temperature ever recorded in a given locality. Such temperatures are usually of short duration and are rarely repeated in successive years. It is therefore evident that a temperature somewhat higher than the lowest on record may be properly assumed in making the heat-loss computations.

The outside temperature to be assumed in the design of any heating system must not be more than 15 deg. fahr. above the lowest recorded temperature as reported by the Weather Bureau (Table 3) during the

TABLE 3. CLIMATIC CONDITIONS COMPILED FROM WEATHER BUREAU RECORDS

COL. A	COL. B	COL. C	COL. D	COL. E	COL. F
State	City	Average Temp., Oct. 1st–May 1st	Lowest Temperature	Average Wind Velocity Dec., Jan., Feb., Miles per Hr.	Direction of Prevailing Wind, Dec., Jan., Feb.
Ala.	Mobile	57.7	−1	8.3	N
	Birmingham	53.9	−10	8.6	N
Ariz.	Phoenix	59.5	16	3.9	E
	Flagstaff	34.9	−25	6.7	SW
Ark.	Fort Smith	49.5	−15	8.0	E
	Little Rock	51.6	−12	9.9	NW
Cal.	San Francisco	54.3	29	....	N
	Los Angeles	58.6	28	....	NE
Colo.	Denver	39.3	−29	7.4	S
	Grand Junction	39.2	−16	5.6	SE
Conn.	New Haven	38.0	−14	9.3	N
D. C.	Washington	43.2	−15	7.3	NW
Fla.	Jacksonville	61.9	10	8.2	NE
Ga.	Atlanta	51.4	−8	11.8	NW
	Savannah	58.4	8	8.3	NW
Idaho	Lewiston	42.5	−13	4.7	E
	Pocatello	36.4	−20	9.3	SE
Ill.	Chicago	36.4	−23	17.0	SW
	Springfield	39.9	−24	10.2	NW
Ind.	Indianapolis	40.2	−25	11.8	S
	Evansville	44.1	−15	8.4	S
Iowa	Dubuque	33.9	−32	6.1	NW
	Sioux City	32.1	−35	12.2	NW
Kans.	Concordia	38.9	−25	7.3	N
	Dodge City	40.2	−26	10.4	NW
Ky.	Louisville	45.2	−20	9.3	SW
La.	New Orleans	61.5	7	9.6	N
	Shreveport	56.2	−5	7.7	SE
Me.	Eastport	31.1	−23	13.8	W
	Portland	33.6	−17	10.1	NW
Md.	Baltimore	43.6	−7	7.2	NW
Mass.	Boston	37.6	−13	11.7	W
Mich.	Alpena	29.1	−27	11.3	W
	Detroit	35.4	−24	13.1	SW
	Marquette	27.6	−27	11.4	NW
Minn.	Duluth	25.1	−41	11.1	SW
	Minneapolis	29.6	−33	11.5	NW
Miss.	Vicksburg	56.0	−1	7.6	SE
Mo.	St. Joseph	40.3	−24	9.1	NW
	St. Louis	43.3	−22	11.8	NW
	Springfield	43.0	−29	11.3	SE
Mont.	Billings	34.7	−49	....	W
	Havre	27.7	−57	8.7	SW
Nebr.	Lincoln	37.0	−29	10.9	N
	North Platte	34.6	−35	9.0	W
Nev.	Tonopah	39.6	−7	9.9	SE
	Winnemucca	37.9	−28	9.5	NE
N. H.	Concord	33.4	−35	6.0	NW
N. J.	Atlantic City	41.6	−7	10.6	NW
N. Y.	Albany	35.1	−24	7.9	S
	Buffalo	34.7	−14	17.7	W
	New York	40.3	−6	13.3	NW
N. M.	Santa Fe	38.0	−13	7.3	NE

TABLE 3. CLIMATIC CONDITIONS COMPILED FROM WEATHER BUREAU RECORDS—(Continued)

COL. A	COL. B	COL. C	COL. D	COL. E	COL. F
State or Province	City	Average Temp., Oct. 1st–May 1st	Lowest Temperature	Average Wind Velocity Dec., Jan., Feb., Miles per Hr.	Direction of Prevailing Wind, Dec., Jan., Feb.
N. C.	Raleigh	49.7	−2	7.3	SW
	Wilmington	53.1	5	8.9	SW
N. D.	Bismark	24.5	−45	....	NW
	Devil's Lake	18.9	−44	11.4	W
Ohio	Cleveland	36.9	−17	14.5	SW
	Columbus	39.9	−20	9.3	SW
Okla.	Oklahoma City	48.0	−17	12.0	N
Ore.	Baker	34.1	−20	6.0	SE
	Portland	45.9	−2	6.5	S
Pa.	Philadelphia	41.9	−6	11.0	NW
	Pittsburgh	40.8	−20	13.7	NW
R. I.	Providence	37.6	−9	14.6	NW
S. C.	Charleston	56.9	7	11.0	N
	Columbia	53.7	−2	8.0	NE
S. D.	Huron	28.1	−43	11.5	NW
	Rapid City	32.3	−34	7.5	W
Tenn.	Knoxville	47.0	−16	6.5	SW
	Memphis	50.9	−9	9.6	NW
Texas	El Paso	53.0	−2	10.5	NW
	Fort Worth	54.7	−8	11.0	NW
	San Antonio	60.7	4	8.2	N
Utah	Modena	38.1	−24	8.9	W
	Salt Lake City	40.0	−20	4.9	SE
Vt.	Burlington	29.3	−27	12.9	S
Va.	Norfolk	49.1	2	9.0	N
	Lynchburg	45.2	−7	5.2	NW
	Richmond	47.4	−3	7.4	S
Wash.	Seattle	45.3	3	9.1	SE
	Spokane	37.5	−30	....	SW
W. Va.	Elkins	38.8	−21	4.8	W
	Parkersburg	41.9	−27	6.6	S
Wis.	Green Bay	28.6	−36	12.8	SW
	La Crosse	31.2	−43	5.6	NW
	Milwaukee	33.0	−25	11.7	W
Wyo.	Sheridan	31.0	−45	5.3	NW
	Lander	28.9	−36	3.0	NE
Alta.	Edmonton	23.3	−57	4.5	W
B. C.	Victoria	43.8	−2	8.9	N
B. C.	Vancouver	41.7	2	4.2	E
Man.	Winnipeg	17.2	−46	12.4	SW
N. B.	Fredericton	27.1	−35	8.7	NW
N. S.	Yarmouth	35.5	−12	13.0	NW
Ont.	London	32.5	−26	....	....
Ont.	Ottawa	26.9	−33	7.5	W
Ont.	Pt. Arthur	21.6	−51	....	....
Ont.	Toronto	32.0	−26	13.5	SW
P. E. I.	Charlottetown	30.1	−23	8.7	NW
Que.	Montreal	27.4	−27	15.4	SW
Que.	Quebec	24.4	−34	15.0	SW
Sask.	Prince Albert	14.7	−70	3.2	SW
Yukon	Dawson	1.6	−68	....	....

preceding 10 years for the locality in which the heating system is to be installed. The outside temperature assumed and used in the design should always be stated in the heating specifications.

If Weather Bureau reports are not available for the locality in question, then the reports for the station nearest to this locality are to be used, unless some other temperature is specifically stated in the specifications.

In computing the average heat transmission losses for the heating season in the United States the average outside temperature from October 1 to May 1, shall be used. This is to be that reported by the U. S. Weather Bureau during the preceding 10 years, for the locality in question.

Summer

The maximum cooling load in summer may be calculated for an outside dry-bulb temperature not to exceed 95 deg. and a wet-bulb temperature not to exceed 77 deg. While higher outside dry-bulb temperatures are frequently observed they are either of short duration or accompanied by low relative humidities. Weather Bureau reports are frequently misleading in this respect as they report the maximum temperature for the day with the relative humidity, which occurs during a different period and which usually is much higher than the relative humidity occurring at the maximum temperature. Any statement of weather condition which gives a wet-bulb temperature higher than 80 deg. in the United States is questionable.

HEAT LOSSES BY TRANSMISSION

The heat losses of a building are of two kinds: (1) the transmission losses through the walls, floors, roof, ceiling and windows, and (2) the infiltration losses through the cracks, crevices, etc., around doors and windows and through solid materials.

The transmission losses are computed by taking into account the heat transmission coefficients (See par. 5, p. 5) of the walls, roof, etc., of the building. These coefficients may be determined experimentally by test, or they may be computed with sufficient accuracy when certain physical constants are known.

Transmission Coefficients By Test

Hot-Box Method: The standard method of testing built-up wall sections is by means of the guarded hot-box described in the Journal of the American Society of Heating and Ventilating Engineers, Vol. 32, No. 5, May, 1926, which consists of an insulated outer box about 5 ft. x 5 ft. x 5 ft., and an inner box about 3 ft. x 3 ft. x 3 ft., also insulated. The wall specimen is clamped to the open side of the outer box and in this position must come in firm contact with the edges of the open side of the inner box. The air in the inner box is heated by means of a resistance coil wound on a cubical frame, and the temperatures in the two boxes controlled thermostatically to maintain the same temperature in each. Fans are installed to maintain uniform temperatures in these two spaces with a minimum circulation of air.

The heat transferred through the wall specimen is readily estimated from the heat input of the inner box, and the air-to-air coefficient of the specimen for still-air conditions determined by dividing this heat-loss by the area of the specimen through which the heat passes, the temperature difference of the air on the two sides of the specimen and the number of hours of the test.

Nicholls Heat Meter: The Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS has developed an apparatus known as the Nicholls heat meter for the determination of the heat transmission coefficient of any type of construction under natural weather conditions. (See JOURNAL OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Vol. 30, No. 1, January, 1924). The Nicholls heat meter consists essentially of a plate of bakelite, 2 ft. square and ⅛ in. thick. This plate is equipped with thermocouples which are so constructed as to operate as differential pyrometers. A difference in temperature between the two surfaces of the plate produces a difference in electrical potential between the thermocouples.

The plate is calibrated so that this difference in potential, when measured, can be converted into terms of heat transmission through the plate. In connection with this plate, it is also necessary to use several other thermocouples to give the temperature of the air within the building, the temperature of the interior surface of the wall or roof, the temperature of the plate itself, the temperature of the exterior of the wall or roof and the temperature of the exterior air.

Tests have been conducted with the Nicholls heat meter on many types of wall construction, and the results obtained are in close agreement with the computed values for these same constructions.

If tests are made to determine heat transmission coefficients, the inside and outside air temperatures should correspond with those actually existing in heating practice, and the amount of air movement, both on the inside and outside of the test wall, should be definitely stated in reporting the coefficients. Since actual temperature differences vary widely in different parts of the country, it is desirable to adopt some standard basis for testing, such as 80 deg. inside and 0 deg. outside, and in very precise work make a correction for other temperatures. It has been found that the absolute mean temperature of the wall affects the coefficients materially. The coefficient increases with the absolute mean temperature.

If the hot-box method is used, tests are usually run under still-air conditions, which means there was no wind movement during the test over the surfaces of the wall. In practice, some wind movement over the exterior surface of the wall should always be allowed for; hence, still-air coefficients cannot be used in actual work as they do not provide for the normal wind movement over the outside of the building in the locality in question during the heating season. Moreover, still-air transmission coefficients cannot be corrected to provide for moving-air conditions by multiplying by a single constant factor.

It would be obviously impossible to determine the air-to-air heat transmission coefficients of every type of wall construction in use with the heat meter or the hot-box on account of the great amount of time involved. Hence, the method of computing the coefficients from fundamental constants must be resorted to in most cases, but heat-meter and the hot-box tests can be used to good advantage in checking the accuracy of the computed values.

Transmission Coefficients by Computation

Symbols and Definitions: The following symbols which are in agreement with the recommendations of the Committee on Heat Transmission of the *National Research Council* are used in the heat transmission formulae in this chapter:

U = Thermal transmittance or overall coefficient of heat transmission and is the amount of heat expressed in B.t.u. transmitted in one hour per square foot of the wall, floor, roof or ceiling for a difference in temperature of 1 deg. fahr. between the air on the inside and outside of the wall, floor, roof or ceiling.

k = Thermal conductivity and is the amount of heat expressed in B.t.u. transmitted in one hour through 1 sq. ft. of a homogeneous material 1 in. thick for a difference in temperature of 1 deg. fahr. between the two surfaces of the material. The conductivity of any material depends on the structure of the material and its density. Heavy or dense materials, the weight of which per cubic foot is high, usually transmit more heat than light or less dense materials, the weight of which per cubic foot is low.

C = Thermal conductance and is the amount of heat expressed in B.t.u. transmitted in one hour through 1 sq. ft. of a non-homogeneous material for the thickness or type under consideration for a difference in temperature of 1 deg. fahr. between the two surfaces of the material. Conductance is usually used to designate the heat transmitted through such heterogeneous materials as plaster board and hollow clay tile.

f = Film or surface conductance and is the amount of heat expressed in B.t.u. transmitted by radiation, conduction and convection from a surface to the air surrounding it, or vice versa, in one hour per square foot of the surface for a difference in temperature of 1 deg. between the surface and the surrounding air. To differentiate between inside and outside wall (or floor, roof or ceiling) surfaces, f_i is used to designate the inside surface or film-conductance and f_o the outside surface or film-conductance.

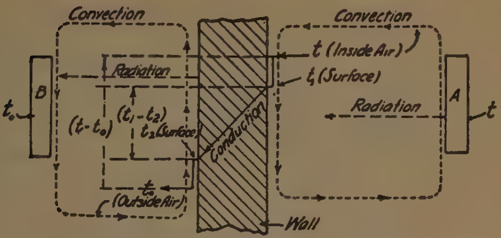
a = Thermal conductance of an air space and is the amount of heat expressed in B.t.u. transmitted by radiation, conduction and convection in one hour through an area of 1 sq. ft. of an air space for a temperature difference of 1 deg. fahr. The conductance of an air space depends on the mean absolute temperature, the width, the position and the character of the materials enclosing it.

R = Resistance or resistivity, the reciprocal of transmission, conductance or conductivity, *i.e.:*

$\frac{1}{U}$ = overall or air-to-air resistance.
$\frac{1}{k}$ = internal resistivity.
$\frac{1}{C}$ = internal resistance.
$\frac{1}{f}$ = surface or film-resistance.
$\frac{1}{a}$ = air-space resistance.
x = thickness in inches.

Fundamental Formulae: If heat transmission coefficients are to be computed, and in many, if not most cases, they should be computed, the following analysis of the transmission of heat through a simple, solid wall is used as the basis for such computations.

The diagram in Fig. 1 exhibits four important temperatures: *First*, the air temperature t inside of the building; *second*, the temperature t_1 of the inside surface of the wall; *third*, the temperature t_2 of the outside



A represents warm surfaces at temperature *t* of inside air; *B* represents cold surfaces at temperature t_0 of outside air. For an actual temperature gradient curve see Fig. 2.

FIG. 1. TEMPERATURE CURVE OR GRADIENT FROM AIR INSIDE TO AND THROUGH WALL TO AIR OUTSIDE, WALL MATERIAL ASSUMED AIR-TIGHT

surface of the wall, and *fourth*, the air temperature t_0 outside of the building.

Heat reaches or enters the inside surface of the wall by radiation and convection, since the air and objects *A* within the building are always warmer than the inside surface of the wall, when the inside air temperature *t* is greater than the outside air temperature t_0. This heat must then pass through the material of the wall from inside to outside surface by conduction, and is finally given off from the outside surface by radiation and

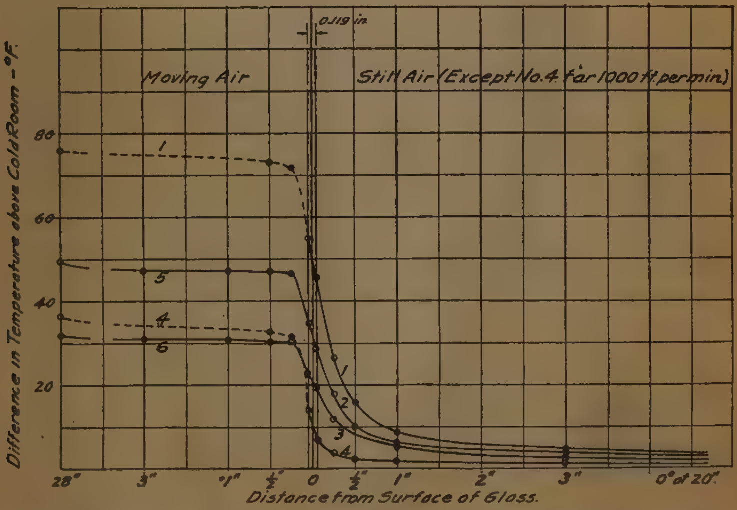


FIG. 2. TEMPERATURE GRADIENT CURVES FOR GLASS (TAKEN FROM BULLETIN NO. 24, ENGINEERING EXPERIMENT STATION, PENNSYLVANIA STATE COLLEGE)

convection, provided, of course, that equilibrium has been established and all four temperatures are constant.

The amount of heat reaching or entering the wall per hour depends on t and t_1 and the coefficient f_i varying with the character of the wall material. The symbol f_i may be defined as the B.t.u. per hour entering each square foot of wall surface per degree difference between the inside air temperature t and the inside surface temperature t_1. Hence, the heat received by the inner surface of the wall per hour by both radiation and convection is:

$$H_1 = f_i\,(t - t_1)\,S \qquad (1)$$

where S is the inner-wall surface area in square feet and the other terms are as heretofore indicated.

Whatever amount of heat H_1 enters the inner-wall surface must be given off from the outer-wall surface, so that if H_2 represents heat emitted from outer surface,

$$H_1 = H_2 = f_o\,(t_2 - t_o)\,S \qquad (2)$$

Now f_o may not equal f_i, in which case $(t_2 - t_o)$ will not equal $(t - t_1)$. Usually, in an actual wall exposed to wind on the outside, f_o (Table 5) is greater than f_i and $(t_2 - t_o)$ must be less than $(t - t_1)$. Moreover, the heat H_c passing through the wall by conduction is equal to H_1 and H_2, and if k is the thermal conductivity expressed in B.t.u. transmitted per hour per square foot of material per 1 in. thickness per degree difference between the surface temperatures, then

$$H_1 = H_2 = H_c = \frac{k}{x}\,(t_1 - t_2)\,S \qquad (3)$$

where x = wall thickness in inches.

These equations (1), (2) and (3) are fundamental and are used for determining values for f_i, f_o and k for actual wall materials by test. They cannot be used for computing heat losses in an actual building, since the surface temperatures t_1 and t_2 are seldom known, although these surface temperatures can be determined in a test by means of thermocouples. Hence, for actual conditions where the only temperatures known are the inside and outside air temperatures t and t_o, it is necessary to use the transmission coefficient U = B.t.u. transmitted per hour per square foot of wall surface per degree difference between the inside and outside air temperatures. Values of U for many common types of construction are given in Tables 12 to 36, inclusive. The heat H transmitted per hour from air inside to air outside is then computed as follows:

$$H = U\,(t - t_o)\,S \qquad (4)$$

and since $H = H_1 = H_2 = H_c$, the right-hand members of equations (1), (2), (3) and (4) are all equal.

The coefficient U may be computed for any wall provided values for f_i, f_o and k are known. By proper substitution in the four equations, the unknown temperatures t_1 and t_2 can be eliminated and the value of the transmission coefficient for a simple wall x inches thick is:

$$U = \frac{1}{\frac{1}{f_i} + \frac{1}{f_o} + \frac{x}{k}} \qquad (5)$$

and for a compound wall of several materials having thicknesses in inches of x_1, x_2, x_3, etc., the coefficient is:

$$U = \frac{1}{\frac{1}{f_i} + \frac{1}{f_o} + \frac{x_1}{k_1} + \frac{x_2}{k_2} + \frac{x_3}{k_3} + etc.} \qquad (6)$$

As in the case of the simple wall, f_i and f_o, are always the inside and outside surface coefficients for the two materials in contact with air. If the air is still (no wind), then for the same material f_i and f_o are the same, and $f_i = f_o$; but, if the outside air is in motion, then f_o is always greater than f_i and will increase as the wind velocity increases. Values for f_i in still air, as determined by various investigators, are given in Table 4.

TABLE 4. SURFACE COEFFICIENTS (f_i) FOR VARIOUS BUILDING MATERIALS UNDER STILL AIR (NO WIND) CONDITIONS

THE VALUES IN THE TABLE ARE IN B.T.U. PER SQUARE FOOT OF WALL SURFACE PER HOUR PER 1 DEG. FAHR. DIFFERENCE BETWEEN THE MEAN AIR TEMPERATURE IN THE ROOM AND THE INSIDE SURFACE TEMPERATURE OF THE WALL.

BUILDING MATERIAL	SURFACE COEFFICIENT f_i (STILL AIR)	
	Harding and Willard	Wood
Asbestos (sheet)	1.40	....
Brickwork (ordinary)	1.40	....
Cement Plaster (finished)	0.93	....
Concrete	1.30	....
Corkboard	1.25	1.20
Glass (window)	1.50	1.90[a]
Magnesia (blocks)	1.45	....
Wood (finished surface)	1.40	....
Building paper	....	1.40
Average of all values	1.34	....

[a] Average of both sides of glass 0.12 in. thick and for 70 deg. fahr. total temperature difference from air to air with moving air on one side. Probable value for still air on both sides 1.60.

Values for k and C, the conductivity and conductance of building materials and insulations, are given in Tables 7, 8, 9, 10 and 11, and are taken from the published values of various investigators. It should be noted that values of k and C as well as U are dependent on the temperature range, and it is therefore desirable that the investigator determine heat-transmission values under conditions approximating those existing under actual conditions.

In the case of air-space construction, an air-space coefficient for each air space must be inserted in either equation (5) or (6). Thus for a simple wall with one air space,

$$U = \frac{1}{\frac{1}{f_i} + \frac{1}{f_o} + \frac{1}{a} + \frac{x}{k}} \qquad (7)$$

and for a simple wall of several air spaces having conductances of a_1, a_2, a_3, etc., the coefficient is:

$$U = \frac{1}{\frac{1}{f_i} + \frac{1}{f_o} + \frac{x}{k} + \frac{1}{a_1} + \frac{1}{a_2} + \frac{1}{a_3} + etc.} \qquad (8)$$

With certain special forms of materials which have irregular air spaces (such as hollow tile) or are otherwise non-homogeneous, it is necessary to use the conductance (C) for the unit construction, in which case $\frac{x}{k}$ is replaced by $\frac{1}{C}$.

Air Spaces and Surface Coefficients: The following from Bulletin No. 102 of the Engineering Experiment Station of the University of Illinois, is pertinent:

> In making calculations for heat transmission coefficients of compound walls, an air space may be treated in either of the following ways: the air space may be regarded as a solid insulating material through which the heat passes according to the so-called conductivity theory or considering the transfer by the three methods, radiation, convection, and conduction, the radiation and convection action may be combined into a single surface coefficient and the true conductivity of the air neglected. For every air space two surface coefficients, accordingly, would be considered. If different surfaces enclosed the air space, different surface coefficients would be used for the two walls.

Because reliable air-space conductance values have not been available until recently, it has been the practice in the past, when calculating the heat transmission through constructions containing air spaces, to assign still-air surface values to the surfaces enclosing the air spaces, rather than to consider the air spaces as solid insulating materials. In the 1928 and 1929 editions of THE GUIDE the heat transmission tables were based on the average value of 1.34 for surfaces in still air taken from Table 4, which is equivalent to an air-space conductance of 0.67 B.t.u. per hour per square foot per degree fahrenheit difference in temperature between the two sides.

According to tests conducted at the University of Minnesota, under the direction of Prof. F. B. Rowley, conductances of air spaces for various widths and mean temperatures average somewhat higher than 0.67 (Table 6). These tests indicate that there is practically no increase in the conductance of an air space beyond about 1 in. in width, and that the average conductance of air spaces of this width or greater at a mean temperature of 40 deg. fahr. is about 1.10 B.t.u. per hour per square foot per degree fahrenheit difference in temperature, although this value is probably sufficiently accurate for all air spaces of ½ in. or more in width.

Surface coefficients increase with the velocity of air passing over the surface. Factors for determining conductances of outside surfaces under moving-air conditions are given in Table 5. It is the practice to increase the still-air surface coefficient by the factor 3 to allow for moving-air conditions, which is approximately equivalent to a wind exposure of 15 miles per hour. Thus, the conductance of the average surface for still air is 1.34, based on the values given in Table 4, and when increased by the factor 3 to allow for moving air, the outside surface coefficient is 3 × 1.34 or 4.02 B.t.u. per hour per square foot per degree fahrenheit difference between the surface and the air in contact with it.

The overall transmission of any wall for a wind exposure other than 15 miles per hour, can be computed by assigning the proper outside surface coefficient, but in most cases the accuracy involved does not warrant this degree of refinement, and it is sufficiently accurate to base all calculations on the one wind exposure. For example: If the heat transmission coefficient of a certain wall is 0.20 based on the outside surface coefficient of 4.02 for a 15-mile wind velocity, this coefficient would not vary more than 1 per cent, plus or minus, for a variation in the wind velocity of 5 miles per hour, plus or minus, based on data contained in Table 5. Computed coefficients are not accurate to this degree of variation in most cases, particularly when it is considered that overall coefficients will often vary to a much greater extent with the density of the materials used in the construction, the moisture content, the mean temperature, the quality of workmanship, and other factors.

TABLE 5. FACTORS TO BE USED IN DETERMINING VALUES OF OUTSIDE SURFACE COEFFICIENTS (f_o) UNDER MOVING AIR CONDITIONS

IN EACH CASE, THE MOVING AIR FACTOR IS BASED ON STILL AIR COEFFICIENT f_i FOR *same* MATERIAL. FOR CONDITIONS WHERE WIND VELOCITY IS NOT KNOWN USE THE FACTOR (3) OR TAKE f_o AS 3 f_i FOR SAME MATERIAL.

WIND VELOCITY IN MILES PER HOUR	BRICKWORK	MULTIPLIERS OF f_i[a] WOOD	AVERAGE
5	2.38	2.19	2.28
10	3.20	2.71	2.96
15	3.76	2.95	3.36[b]
20	4.22	3.02	3.62
Additional Values—Smooth Surface			
10	--------	2.20	--------
20	--------	2.60	--------
Above 20	--------	3.00	--------

[a] Taken from Engineering Experiment Station Bulletin No. 102, of the University of Illinois. Additional values from Engineering Experiment Station, Pennsylvania State College, reported by Professor Wood. Tests at Pennsylvania State College indicate character of surface, rough or smooth, more important than material of surface.

[b] This is usually taken as 3 even.

Conductivities and Conductances: The majority of the conductivities and conductances of the building materials and insulations given in Tables 7, 8, 9, 10 and 11, were determined by the hot-plate method of testing. (See Standard Test Code for Heat Transmission Through Walls, JOURNAL OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, January, 1928, p. 63.) Attention is called to the fact that conductivities per inch of thickness of materials or insulations do not afford a true basis for comparison, although they are frequently used for that purpose. Correct comparisons should take into consideration many different factors, including conductivities or conductances, thicknesses installed, manner of installation, etc., while the selection of an insulation should also give consideration to structural qualities, as well as material and application costs. At present there is no universally recognized method of rating insulations. Conductivities and conductances of building materials and insulations are useful to the heating engineer in deter-

TABLE 6. CONDUCTANCES OF AIR SPACES[a] AT VARIOUS MEAN TEMPERATURES

MEAN TEMP. DEG. FAHR.	CONDUCTANCE OF AIR SPACES FOR VARIOUS WIDTH IN INCHES						
	0.128	0.250	0.364	0.493	0.713	1.00	1.500
20	2.300	1.370	1.180	1.100	1.040	1.030	1.022
30	2.385	1.425	1.234	1.148	1.080	1.070	1.065
40	2.470	1.480	1.288	1.193	1.125	1.112	1.105
50	2.560	1.535	1.340	1.242	1.168	1.152	1.149
60	2.650	1.590	1.390	1.295	1.210	1.195	1.188
70	2.730	1.648	1.440	1.340	1.250	1.240	1.228
80	2.819	1.702	1.492	1.390	1.295	1.280	1.270
90	2.908	1.757	1.547	1.433	1.340	1.320	1.310
100	2.990	1.813	1.600	1.486	1.380	1.362	1.350
110	3.078	1.870	1.650	1.534	1.425	1.402	1.392
120	3.167	1.928	1.700	1.580	1.467	1.445	1.435
130	3.250	1.980	1.750	1.630	1.510	1.485	1.475
140	3.340	2.035	1.800	1.680	1.550	1.530	1.519
150	3.425	2.090	1.852	1.728	1.592	1.569	1.559

[a] *Thermal Resistance of Air Spaces*, By F. B. Rowley and A. B. Algren (JOURNAL, A. S. H. V. E., Vol. 35, No. 1, January, 1929).

mining overall coefficients of heat transmission of walls, floors, roofs and ceilings.

Computed Transmission Coefficients: As previously stated heat transmission coefficients of many common types of building construction are given in Tables 12 to 36, inclusive, each construction being identified by a serial number. For example: The coefficient of transmission (U) of a 12-in. brick wall, furring strips, and ¾-in. of gypsum plaster on metal lath, is 0.216, and the number assigned to a wall of this construction is *3-B*, Table 12.

The coefficients in these tables were determined by computations similar to those shown in Fig. 3, using the value of k (or C) indicated. The authorities for the conductivities used for computing these coefficients are given in Tables 7, 8, 9, 10 and 11. As in the case of the examples in Fig. 3, the average value of 1.34 given in Table 4 for f_i was used for all surfaces in still air. The value of f_o for outside wall and roof surfaces was taken as $3 \times f_i$, or 4.02, corresponding to a wind velocity of approximately 15 miles per hour. The conductance of air spaces ½ in. or more in width was taken to be 1.10 B.t.u. per hour per square foot per degree fahrenheit difference between the two sides enclosing the air space. (See Table 6.)

Problems involving the determination of the value of U from the conductivity constants can also be solved by what is sometimes known as the resistance method which is readily derived from the basic equation No. 5 as follows:

$$\frac{1}{U} = \frac{1}{f_i} + \frac{1}{f_o} + \frac{x}{k} = \Sigma\,[R_i + R_o + R_r]$$

or (9)

$$U = \frac{1}{\Sigma\,[R_i + R_o + R_r]}$$

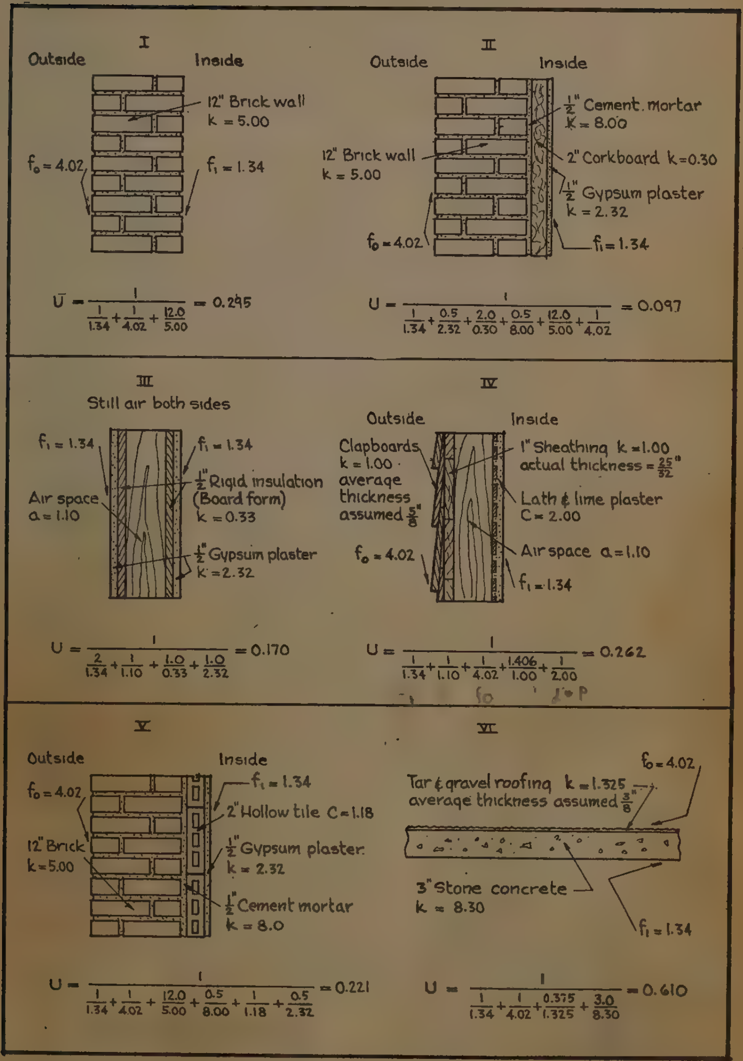

I
Outside
Inside
12" Brick wall
k = 5.00
$f_o = 4.02$
$f_i = 1.34$
$U = \frac{1}{\frac{1}{1.34}+\frac{1}{4.02}+\frac{12.0}{5.00}} = 0.295$
II
Outside
Inside
$\frac{1}{2}$" Cement mortar
k = 8.00
2" Corkboard k = 0.30
$\frac{1}{2}$" Gypsum plaster
k = 2.32
12" Brick wall
k = 5.00
$f_o = 4.02$
$f_i = 1.34$
$U = \frac{1}{\frac{1}{1.34}+\frac{0.5}{2.32}+\frac{2.0}{0.30}+\frac{0.5}{8.00}+\frac{12.0}{5.00}+\frac{1}{4.02}} = 0.097$
III
Still air both sides
$f_i = 1.34$
$f_i = 1.34$
Air space
a = 1.10
$\frac{1}{2}$" Rigid insulation (Board form)
k = 0.33
$\frac{1}{2}$" Gypsum plaster
k = 2.32
$U = \frac{1}{\frac{2}{1.34}+\frac{1}{1.10}+\frac{1.0}{0.33}+\frac{1.0}{2.32}} = 0.170$
IV
Outside
Inside
Clapboards
k = 1.00
average thickness assumed $\frac{5}{8}$"
1" Sheathing k = 1.00
actual thickness = $\frac{25}{32}$"
Lath & lime plaster
C = 2.00
Air space a = 1.10
$f_o = 4.02$
$f_i = 1.34$
$U = \frac{1}{\frac{1}{1.34}+\frac{1}{1.10}+\frac{1}{4.02}+\frac{1.406}{1.00}+\frac{1}{2.00}} = 0.262$
V
Outside
Inside
$f_o = 4.02$
$f_i = 1.34$
2" Hollow tile C = 1.18
12" Brick
k = 5.00
$\frac{1}{2}$" Gypsum plaster
k = 2.32
$\frac{1}{2}$" Cement mortar
k = 8.0
$U = \frac{1}{\frac{1}{1.34}+\frac{1}{4.02}+\frac{12.0}{5.00}+\frac{0.5}{8.00}+\frac{1}{1.18}+\frac{0.5}{2.32}} = 0.221$
VI
$f_o = 4.02$
Tar & gravel roofing k = 1.325
average thickness assumed $\frac{3}{8}$"
3" Stone concrete
k = 8.30
$f_i = 1.34$
$U = \frac{1}{\frac{1}{1.34}+\frac{1}{4.02}+\frac{0.375}{1.325}+\frac{3.0}{8.30}} = 0.610$

FIG. 3. EXAMPLES SHOWING METHOD OF COMPUTING HEAT TRANSMISSION COEFFICIENTS OF VARIOUS TYPES OF CONSTRUCTION

The internal resistance of a material is equal to the reciprocal of its so-called internal conductivity (k) multiplied by its thickness and is represented by the fraction $\frac{x}{k}$, or $\frac{1}{C}$, in the case of materials for which the conductance is given in terms of the construction or thickness stated. For example: The internal resistance of 12 in. of brickwork on the basis of a value of k of 5.0 is $\frac{12}{5}$ or 2.40. The internal resistance of 2-in. hollow clay tile based on the value of C of 1.18 is $\frac{1}{1.18}$ or 0.847.

In the resistance method, the sum of the internal resistances of all the materials entering into the construction, is added to the sum of the surface resistances, which are the reciprocals of the surface coefficients or $\frac{1}{f}$. The resistance of a surface in still air, based on the average value of f_i or 1.34 is $\frac{1}{1.34}$ or 0.746. The resistance of an outside surface exposed to the wind, based on the average value of f_o or 4.02 (3×1.34) is $\frac{1}{4.02}$ or 0.249. The computed value of U obtained by the resistance method is obtained by taking the reciprocal of the sum of the internal and surface resistances of the construction. The solution of Example V in Fig. 3, by means of the resistance method is given in the following summary:

MATERIAL	THICKNESS INCHES	INTERNAL CONDUCTIVITY OR CONDUCTANCE	SURFACE COEFFICIENTS f_i or f_o	INTERNAL RESISTANCE	SURFACE RESISTANCE
Brickwork	12	5.0 (k)	4.02 (f_o)	2.400	0.249
Cement Mortar	½	8.0 (k)		0.063	
Hollow Clay Tile	2	1.18 (C)		0.847	
Plaster (gypsum)	½	2.32 (k)	1.34 (f_i)	0.215	0.746
				3.525	0.995
					3.525
Total resistance (R)					4.520

$$U = \frac{1}{R} = \frac{1}{4.520} = 0.221 \text{ B.t.u. per hour per square foot per 1 deg. fahr.}$$
difference in temperature between the air on the two sides of the wall.

In computing heat transmission coefficients of floors laid directly on the ground (Table 31), only one surface coefficient (f_i) is used. For example, the value of U for a 1 in. yellow pine floor (actual thickness, 25/32 in.) placed directly on 5 in. concrete on the ground, is determined as follows:

$$U = \frac{1}{\frac{1}{1.34} + \frac{0.781}{1.00} + \frac{5.0}{8.30}} = 0.472 \text{ B.t.u. per hour per square foot}$$

per 1 deg. fahr. difference in temperature between the ground and the air immediately above the floor.

Table 7. Conductivities (k) and Conductances (C) of Building Materials and Insulations

Based on Tests Conducted at the U. S. Bureau of Standards[p]

Note.—The coefficients in Tables 7–11, incl., are expressed in B.t.u. per hour per square foot, per 1 deg. Fahr., per 1 in. thickness unless otherwise indicated by Note [b].

Material	Description	Density (Lb. per Cu. Ft.)	Mean Temp. (Deg. Fahr.)	Conductivity (k) or Conductance (C)[a]
Asbestos Wood	Asbestos and cement compressed	123.0	86	2.70
Asbestos Mill Board	Pressed asbestos	60.5	86	0.84
Balsam Wool[h]	Chemically treated wood fiber between layers of paper	2.2	90	0.27
Cabots Quilt[h]	Eel grass between Kraft paper	4.6	90	0.26
Cabots Quilt[h]	Eel grass between Kraft paper	3.4	90	0.25
Celotex	Rigid insulation made from sugar cane fiber	13.2	90	0.34
Corkboard	Pure; no added binder	14.0	90	0.34
Corkboard	Pure; no added binder	10.6	90	0.30
Corkboard	Pure; no added binder	7.0	90	0.27
Corkboard (Eureka)	Asphaltic binder	14.5	90	0.32
Dry Zero[h]	Kapok between burlap or paper	1.0	90	0.24
Fibrofelt[h]	Flax and rye fiber	13.6	90	0.32
Flaxlinum[h]	Flax fiber	13.0	90	0.31
Gyplap	Gypsum between layers of heavy paper (½ in. thick)	53.5	90	2.60[b]
Hairinsul[h]	75% hair; 25% jute	6.3	90	0.27
Hairinsul[h]	50% hair; 50% jute	6.1	90	0.26
Hair Felt[h]	Felted cattle hair	13.0	90	0.26
Hair Felt[h]	Felted cattle hair	11.0	90	0.26
Insulex or Pyrocell	Cellular gypsum—dry	30.0	90	1.00
Insulex or Pyrocell	Cellular gypsum—dry	24.0	90	0.77
Insulex or Pyrocell	Cellular gypsum—dry	18.0	90	0.59
Insulex or Pyrocell	Cellular gypsum—dry	12.0	90	0.44
Insulite	Rigid insulation made from wood pulp	16.9	90	0.34
Linofelt[h]	Flax fibers between paper	4.9	90	0.28
Lith	Rock wool, flax and straw pulp with binder	14.3	90	0.40
Magnesia (Rigid)	85% magnesia, 15% asbestos	19.3	86	0.51
Plaster	Gypsum	46.2	86	2.32[i]
Regranulated cork	About 3/16 in. particles	8.1	90	0.31
Rock cork	Rock wool block with binders	16.7	86	0.37
Rock wool	Fibrous material, made from rock	10.0	90	0.27
Rock wool	Fibrous material made from rock	14.0	90	0.28
Rock wool	Fibrous material made from rock	18.0	90	0.29
Rock wool	Fibrous material made from rock	21.0	90	0.30
Sawdust	Ordinary	———	86	1.04
Shavings	Ordinary	———	86	0.71
Sheetrock	Gypsum mixed with sawdust between layers of heavy paper (0.39 in. thick)	60.7	90	3.60[b]
Sprayo-Flake	Shredded paper with silica binder	4.2	94	0.28
Thermofelt[h]	Jute and asbestos fibers, felted	10.0	90	0.37
Thermofelt[h]	Hair and asbestos fibers, felted	7.8	90	0.28
Thermofill	Dry, fluffy, flaked gypsum	34.0	90	0.60
Thermofill	Dry, fluffy, flaked gypsum	26.0	90	0.52
Thermofill[h]	Dry, fluffy, flaked gypsum	19.8	90	0.35
Torfoleum	Peat moss compressed into sheet form	10.2	91.5	0.29
Woods:				
Balsa wood	Across grain	20.0	90	0.58
Balsa wood	Across grain	8.8	90	0.38
Balsa wood	Across grain	7.3	90	0.33
Cypress	Across grain	28.7	86	0.67
Maple	Across grain	44.3	86	1.10
Mahogany	Across grain	34.3	86	0.90
Virginia Pine	Across grain	34.3	86	0.96
White Pine	Across grain	31.2	86	0.78

[a] In addition to the conductivity values for the authorities listed, considerable work of importance pertaining to the heat transmission of various types of construction and materials has been done by the late Prof. John R. Allen and Prof. A. J. Wood of the Engineering Experiment Station of Pennsylvania State College.

[b] For thickness stated or used in construction, not per 1 in. thickness.

[h] Not compressed.

[i] The conductivity of plaster varies with the composition. Note range of values from 2.32 to 8.0. The average value for plaster is probably about 5.0. On account of the comparatively high conductivity of plaster and the fact that it is seldom applied more than ¾ in. thick, this material does not appreciably effect the overall transmission of a construction, excepting in the case of thin uninsulated walls.

[p] See Chapter LX, by Chas. H. Herter of the Report of the Insulation Committee, *A. S. R. E.*, Annual Meeting 1922, Revised to 1924, entitled, Heat Transmission of Insulating Materials for a more comprehensive collection of heat transmission data relating to building and insulating materials.

The thicknesses upon which the coefficients in Tables 12 to 36, inclusive, are based, are as follows:

Brick veneer	4 in.
Plaster and metal lath	¾ in.
Plaster (on wood lath, plasterboard, rigid insulation, board form, or corkboard)	½ in.
Slate (Roofing)	½ in.
Stucco on wire mesh reinforcing	1 in.
Tar and gravel or slag-surfaced built-up roofing	⅜ in.
Wood shingles (average thickness)	⅝ in.
Wood siding or clapboard (average thickness)	⅝ in.
1-in. Lumber (S-2-S)	25/32 in.
1½-in. Lumber (S-2-S)	1 5/16 in.
2-in. Lumber (S-2-S)	1⅝ in.
2½-in. Lumber (S-2-S)	2⅛ in.
3-in. Lumber (S-2-S)	2⅝ in.
4-in. Lumber (S-2-S)	3⅝ in.
Finish flooring (Maple or Oak)	1 3/16 in.

TABLE 8. CONDUCTIVITIES (*k*) AND CONDUCTANCES (*C*) OF BUILDING MATERIALS AND INSULATIONS

Based on Tests Conducted at the University of Illinois,
By A. C. Willard, L. C. Lichty and L. A. Harding[p]

MATERIAL	DESCRIPTION	DENSITY (LB. PER CU. FT.)	MEAN TEMP. (DEG. FAHR.)	CONDUCTIVITY[a] (*k*) OR CONDUCTANCE (*C*)
Asbestos	Sheet	48.3	110	0.29
Asbestos Board	Corrugated	20.4	110	0.48
Brickwork	Mortar bond and dry conditions	132.0	100	4.00
Brickwork	Damp or wet	......	......	5.00[j]
Cement mortar	......	......	......	8.00[f]
Concrete	Stone 1-2-4 mix	140.0	110	8.30
Corkboard	Pure; no added binder	9.7	......	0.32
2 in. hollow clay tile, ½ in. plaster both sides	......	120.0	110	1.00[b]
4 in. hollow clay tile, ½ in. plaster both sides	......	127.0	100	0.60[b]
6 in. hollow clay tile, ½ in. plaster both sides	......	124.3	105	0.47[b]
Magnesia Board	......	13.5	110	0.51
Plaster	Cement	......	......	8.00[i]
Roofing[g]	Built-up bitumen and felt, gravel or slag surfaced	......	......	1.325[d]
Roofing[g]	Built-up bitumen and felt, gravel or slag surfaced	......	......	5.30[d-b]
Stucco	......	......	......	8.00[f]
Wood (Fir, one-surface finished	Across grain	33.4	......	1.00

[a] In addition to the conductivity values for the authorities listed, considerable work of importance pertaining to the heat transmission of various types of construction and materials has been done by the late Prof. John R. Allen and Prof. A. J. Wood of the Engineering Experiment Station of Pennsylvania State College.

[b] For thickness stated or used in construction, not per 1 in. thickness.

[d] Calculated from 2 in. tile tests.

[f] Cement mortar and stucco assumed same as cement plaster.

[g] Roofing, 0.15 in. thick (1.34 lb. per sq. ft.), covered with gravel (0.83 lb. per sq. ft.), combined thickness assumed 0.25.

[i] The conductivity of plaster varies with the composition. Note range of values from 2.32 to 8.0. The average value for plaster is probably about 5.0. On account of the comparatively high conductivity of plaster and the fact that it is seldom applied more than ¾ in. thick, this material does not appreciably effect the overall transmission of a construction, excepting in the case of thin uninsulated walls.

[j] Recommended value. See *Mechanical Equipment of Buildings*, by Harding and Willard, Vol. I, second edition, 1929, p. 182.

[p] See Chapter LX, by Chas. H. Herter of the Report of the Insulation Committee, *A. S. R. E.*, Annual Meeting, 1922, Revised to 1924, entitled, Heat Transmission of Insulating Materials for a more comprehensive collection of heat transmission data relating to building and insulating materials.

TABLE 9. CONDUCTIVITIES (k) AND CONDUCTANCES (C) OF BUILDING MATERIALS AND INSULATIONS

Based on Tests Conducted at Armour Institute of Technology, By J. C. Peebles[p]

MATERIAL	DESCRIPTION	DENSITY (LB. PER CU. FT.)	MEAN TEMP. (DEG. FAHR.)	CONDUCTIVITY[a] (k) OR CONDUCTANCE (C)
Aerocrete	Cellular concrete	40.0	75	1.06
Aerocrete	Cellular concrete	50.0	75	1.44
Aerocrete	Cellular concrete	60.0	75	1.80
Aerocrete	Cellular concrete	70.0	75	2.18
Asbestos shingles	....	65.0	75	6.00[b]
Asphalt shingles	....	70.0	75	6.50[b]
Balsam Wool[h]	Chemically treated wood fibre with with plain paper	3.62	70	0.25
Beaver Fibre Wallboard	Commercial thickness 3/16 in.	----	----	0.50
Calicel	Granular fill insulation made from combined silicate of lime and alumina	4.2	72	0.24
Celotex	Rigid insulation made from sugar cane fibre	13.5	70	0.33
Certainteed Insulating Board	Commercial thickness 7/16 in.	25.9	----	0.39
Concrete	Stone	145.0	75	6.30
Concrete	Cinder	110.0	75	5.20
Dry Zero Blanket[h]	Pliable slab form of insulation made from ceiba fibres	1.9	75	0.23
Dry Zero Blanket[h]	Pliable slab form of insulation made from ceiba fibres	1.6	75	0.24
Dry Zero Blanket[h]	Pliable slab form of insulation made from ceiba fibres	1.5	75	0.24
Flax-li-num[h]	Flax fibre	12.1	70	0.30
Haydite Concrete	Heat treated clay aggregate concrete	73.0	----	1.62
Homasote "A" Building Board	Made from wood and other vegetable fibres chemically treated	22.2	75	0.38
Inso Board	Rigid insulation made from wheat straw	17.0	68	0.33
Insulite	Rigid insulation made from wood pulp	16.5	70	0.34
Keystone Hair[h]	Hair felt between layers of paper; ¼ in. thick	11.0	75	0.25
Lith	Rock wool, flax and straw pulp with binder	14.5	75	0.38
Maftex	Rigid insulation made from licorice roots	16.1	81	0.34
Maple Flooring	Across grain	40.0	75	1.20
Masonite	Rigid insulation made from exploded wood fibre	19.8	75	0.33
Plaster Board	Gypsum between layers of heavy paper	62.8	70	1.41
Pyrocell or Insulex	Cellular gypsum—dry	30.0	75	0.92
Pyrocell or Insulex	Cellular gypsum—dry	24.0	75	0.74
Pyrocell or Insulex	Cellular gypsum—dry	18.0	75	0.57
Pyrocell or Insulex	Cellular gypsum—dry	12.0	75	0.40
Roofing	Composition or prepared	----	75	6.50[b]
Sprayo-Flake	Shredded paper with silica binder	4.5	----	0.25
Thermofil	Dry, fluffy, flaked gypsum	24.0	75	0.48
Thermofil	Dry, fluffy, flaked gypsum	18.0	75	0.34
Thermasote "A" Insulating Board	Made from wood fibre, chemically treated	18.6	75	0.34
Torfoleum	Peat moss compressed into sheet form	11.0	70	0.26
Weatherwood	Rigid insulation made from hard pine fibres	72.0	70	0.32
Wood Lath and Plaster[k]	Lime plaster	----	75	2.0[b]
Yellow Pine	Across grain	----	----	1.00

---

[a] In addition to the conductivity values for the authorities listed, considerable work of importa
taining to the heat transmission of various types of construction and materials has been done by
Prof. John R. Allen and Prof. A. J. Wood of the Engineering Experiment Station of Pennsylva
College.

[b] For thickness stated or used in construction, not per 1 in. thickness.

[h] Not compressed.

[k] Thickness of lime plaster and wood lath from back of lath to face of plaster, about 5/16

[p] See Chapter LX, by Chas. H. Herter of the Report of the Insulation Committee, *A. S*
Meeting, 1922, Revised to 1924, entitled, Heat Transmission of Insulating Materials for
hensive collection of heat transmission data relating to building and insulating material

TABLE 10. CONDUCTIVITIES (k) AND CONDUCTANCES (C) OF BUILDING MATERIALS AND INSULATIONS

Based on Tests Conducted at the University of Minnesota, By F. B. Rowley [p]

MATERIAL	DESCRIPTION	DENSITY (LB. PER CU. FT.)	MEAN TEMP. (DEG. FAHR.)	CONDUCTIVITY (k) OR CONDUCTANCE (C) [a]
Concrete	Stone 1-2-4 mix	143.0	68.8	9.46
Dry Zero	Pliable slab form of insulation made from ceiba fibres	....	....	0.23
Fir sheathing and building paper		....	30.0	0.71[b]
Fir sheathing, building paper and pine lap siding		....	20.0	0.50[b]
Fir sheathing, building paper and stucco		....	20.0	0.82[b]
Gypsum Tile	Solid	51.8	69.9	1.66
Gypsum Tile	Solid	75.6	75.9	2.96
Gypsum Fibre Concrete	87½% gypsum and 12½% wood chips	51.2	74.4	1.66
Lath and ⅜ in. Plaster	Total thickness ¾ in.	....	70.0	2.50[b]
Masonite	Rigid insulation made from exploded wood fibre	17.9	77.6	0.32
Pine lap siding and building paper	Lap siding 4 in. wide	....	15.5	0.85[b]
Plaster	Thickness ⅜ in.	....	73.0	8.8[b]
Sheet Rock Pyrofill Roofing, 2½ in .thick	Plaster board, gypsum fibre concrete and 3-ply roof covering	52.4	76.0	0.58[b]
Sprayo-Flake	Shredded paper with silica binder	5.9	61.1	0.28

[a] In addition to the conductivity values for the authorities listed, considerable work of importance pertaining to the heat transmission of various types of construction and materials has been done by the lat Prof. John R. Allen and Prof. A. J. Wood of the Engineering Experiment Station of Pennsylvania Stat College.

[b] For thickness stated or used in construction, not per 1 in. thickness.

[p] See Chapter LX, by Chas. H. Herter of the Report of the Insulation Committee, *A. S. R. E.*, Annua Meeting, 1922, Revised to 1924, entitled, Heat Transmission of Insulating Materials for a more comprehensive collection of heat transmission data relating to building and insulating materials.

Note that actual thicknesses of lumber are used in the computation rather than nominal thicknesses.

On account of the fact that the internal resistances of metal and singl thicknesses of building paper (used because of its value as a wind sto only) and roofing felt are very small, these resistances were neglected i the calculations, in accordance with standard practice. The computation for wood shingle roofs applied over wood stripping are based on 1 by 4 in wood strips, spaced 2 in. apart. Since no reliable figures are availabl concerning the conductivity of Spanish and French clay roofing tile, o which there are many varieties, the figures for such types of roofs wer taken the same as for slate roofs, as it is probable that the values of U for these two types of roofs will compare favorably.

The coefficients of transmission of the pitched roofs in Table 34 appl ere the roof is over a heated attic or top floor, such that the heat passe ctly through the roof structure including whatever finish, if any, i ed to the underside of the roof rafters. By a heated attic is meant a o which heat is supplied directly from the furnace or boiler b of radiators, warm-air registers, or other means.

attic is unheated, the roof structure and ceiling of the top floo be taken into consideration, and the combined coefficient o n determined. The formula for calculating the combine f transmission of a top-floor ceiling, unheated attic space an per square foot of roof area, is as follows:

$$U = \frac{U_r \times U_{ce}}{n \times U_r + U_{ce}} \tag{10}$$

where

U_r = coefficient of transmission of the roof.
U_{ce} = coefficient of transmission of the ceiling.
n = the ratio of the area of the roof to the area of the ceiling.

In using this formula, a correction-factor must be applied. As the amount of heat transferred through an air space is proportional to the difference of the fourth powers of the absolute temperatures of the surfaces enclosing the air space, a greater amount of heat is absorbed or emitted by radiation by the surfaces enclosing an unheated attic than by the surfaces of a wall or ceiling in a room under still-air conditions, where the surrounding objects are only slightly higher in temperature than the interior surfaces of the walls and ceiling. For example: According to the most reliable information at present available, the average coefficient of a surface in still air is 1.34 B.t.u. per hour per square foot per degree fahrenheit, whereas the average coefficient of an air space in an outside wall is about 1.10 B.t.u. per hour per square foot per degree fahrenheit difference between the two surfaces, at a mean temperature of 40 deg. fahr. An air space coefficient of 1.10 is equivalent to a surface coefficient of 2.20 for each of the two surfaces enclosing the air space, where the overall transmission is computed by using the coefficients of the two surfaces enclosing the air space instead of the coefficient of the air space itself. Hence, in determining the values of U_r and U_{ce} to be used in the formula, the coefficients for the surfaces of the roof and ceiling enclosing the attic should be increased to allow for the additional amount of heat transferred by radiation, and a coefficient of 2.20 may be used with sufficient accuracy for each of these surfaces, although in very precise work a correction should be made to allow for the fact that the area of a pitched roof over an unheated attic is greater than the area of the ceiling, and hence, the amount of heat absorbed by radiation by each square foot of roof surface is less than is given off by radiation by each square foot of ceiling surface.

The following example will illustrate the use of this formula: Determine the combined coefficient of transmission of a roof constructed of asbestos shingles applied over wood sheathing on rafters, an unheated attic, and a wood lath and plaster ceiling, based on a roof having a ⅓ pitch, for which the value of n is 1.2.

$$U_r = \frac{1}{\frac{1}{4.02} + \frac{1}{2.20} + \frac{1}{6.00} + \frac{0.781}{1.00}} = 0.605$$

$$U_{ce} = \frac{1}{\frac{1}{1.34} + \frac{1}{2.20} + \frac{1}{2.00}} = 0.588$$

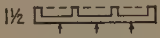
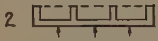
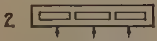
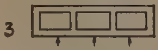
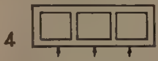
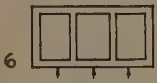
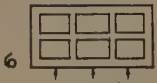
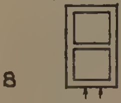
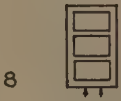
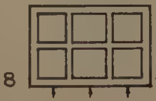
Substituting these values in the preceding formula:

$$U = \frac{0.605 \times 0.588}{1.2 \times 0.605 + 0.588} = 0.271$$

B.t.u. per hour, *per square foot of roof area* per 1 deg. fahr. difference in temperature between the air near the underside of the ceiling and the outside air.

TABLE 11. CONDUCTIVITIES (*k*) AND CONDUCTANCES (*C*) OF BUILDING MATERIALS

Based on Tests Conducted by Various Authorities [p]

MATERIAL	DESCRIPTION	MEAN TEMP. (DEG. FAHR.)	CONDUCTIVITY[a] (*k*) OR CONDUCTANCE (*C*)	AUTHORITY
Concrete	Stone 1-2-5 mix	95[c]	6.27	C. L. Norton, Boston, Mass.
Concrete	Cinder 1-2-4 mix	122	2.35	C. L. Norton, Boston, Mass.
Slate		201	10.37	Lees & Chorlton
Stone	Limestone or Sandstone	------	10.0	Estimated[e]
1½ in. Split Furring Clay Tile			1.40[b]	Estimated[m]
2 in. Split Furring Clay Tile			1.25[b]	Estimated[m]
2 in. Furring Clay Tile			1.18[b]	Estimated[m]
3 in. Furring or Partition Clay Tile			1.00[b]	Estimated[m]
4 in. Partition Clay Tile			0.93[b]	Estimated[m]
6 in. Partition Clay Tile			0.86[b]	Estimated[m]
6 in. Load Bearing Clay Tile			0.54[b]	Estimated[m]
8 in Backup Clay Tile			0.50[b]	Estimated[m]
8 in. Backup Clay Tile			0.39[b]	Estimated[m]
8 in. Load Bearing Clay Tile			0.49[b]	Estimated[m]

---

[a] In addition to the conductivity values for the authorities listed, considerable work of importance pertaining to the heat transmission of various types of construction and materials has been done by the late Prof. John R. Allen and Prof. A. J. Wood of the Engineering Experiment Station of Pennsylvania State College.

[b] For thickness stated or used in construction, not per 1 in. thickness.

[c] Hot side of plate.

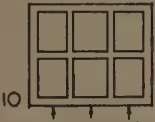
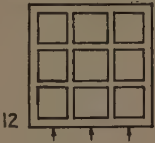
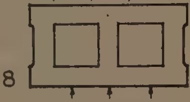
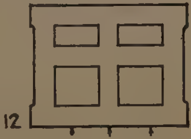
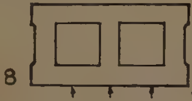
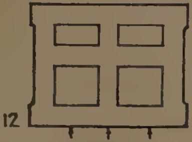
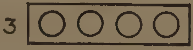
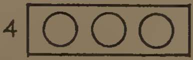
[e] Average of several values.

[m] Estimated from air space conductance data in Table 6, and Burned Clay conductivity of 5.0 per 1 in. Walls of load bearing tile assumed ¾ in. thick and webbs assumed ⅝ in. thick. Walls of all other tile assumed ⅝ in. thick and webbs ½ in. thick.

[p] See Chapter LX, by Chas. H. Herter of the Report of the Insulation Committee, *A. S. R. E.*, Annual Meeting 1922, Revised to 1924, entitled, Heat Transmission of Insulating Materials for a more comprehensive collection of heat transmission data relating to building and insulating materials.

TABLE 11. CONDUCTIVITIES (k) AND CONDUCTANCES (C) OF BUILDING MATERIALS

Based on Tests Conducted by Various Authorities [p]—(Continued)

MATERIAL	DESCRIPTION	MEAN TEMP. (DEG. FAHR.)	CONDUCTIVITY (k) OR CONDUCTANCE (C)	AUTHORITY
10 in. Load Bearing Clay Tile			0.46[b]	Estimated[m]
12 in. Load Bearing Clay Tile			0.33[b]	Estimated[m]
8 in. Concrete Blocks (hollow)			0.84[b]	Estimated[n]
12 in. Concrete Blocks (hollow)			0.52[b]	Estimated[n]
8 in. Cinder Blocks (hollow)			0.45[b]	Estimated[n]
12 in. Cinder Blocks (hollow)			0.28[b]	Estimated[n]
3 in. Gypsum Tile (hollow)			0.55[b]	Estimated[o]
4 in. Gypsum Tile (hollow)			0.46[b]	Estimated[q]
Ten Test	Rigid insulation made from wood fiber	52	0.33	E. A. Allcut University of Toronto

---

[m] Estimated from air space conductance data in Table 6, and Burned Clay conductivity of 5.0 per 1 in. Walls of load bearing tile assumed ¾ in. thick and webbs assumed ⅝ in. thick. Walls of all other tile assumed ⅝ in. thick and webbs ½ in. thick.

[n] Estimated from air space conductance data in Table 6, and conductivity of concrete of 8.30 per 1 in. Shells and webbs assumed 2 in. thick. Conductivity of dry Cinder Concrete assumed 3.33.

[o] Estimated from air space conductance data in Table 6, and conductivity of gypsum tile of 1.66 per 1 in. It is assumed that each tile has 4 cores per 12 in. width, each 1¾ in. in diameter.

[q] Estimated from air space conductance data in Table 6, and conductivity of gypsum tile of 1.66 per 1 in. It is assumed that each tile has 3 cores per 12 in. width, each 2½ in. in diameter.

Combined coefficients for many common types of pitched roofs and top-floor ceilings for unheated attics are given in Table 35.

If the unheated attic space between the roof and ceiling has no dormers, windows or vertical wall surfaces, the combined coefficients given in Table 35 may be used for determining the heat loss through the roof construction between the attic and top-floor ceiling, but it should be noted that the coefficients given in Table 35 should be multiplied by the roof area and not by the ceiling area. If the unheated attic contains windows, ventilators or vertical wall surfaces, which would tend to reduce the temperature in the attic to a temperature approaching or equaling the outside temperature, the roof should be neglected and only the top-floor ceiling construction and the corresponding ceiling area taken into consideration, using the coefficients given in Tables 29 or 30. The attic temperature should then be taken the same as the outside temperature. In this case the reasoning regarding the loss of heat from a surface by radiation, referred to in the preceding discussion regarding the determination of the combined coefficients of a ceiling, unheated attic and roof, does not apply to the heat loss from the attic floor or top-floor ceiling, on account of the fact that the undersurface of the roof will have about the same temperature as the attic floor. As stated before, if the attic is heated, the top-floor ceiling should be neglected, and only the roof structure, with whatever ceiling is applied to the underside of the roof rafters, taken into consideration in determining the heat losses through the roof.

The temperature in an attic space containing no dormers, windows, vertical wall spaces or ventilators may be estimated by means of the following formula:

$$t_b = \frac{t\,U_{ce} + n\,t_o\,U_r}{U_{ce} + n\,U_r} \qquad (10_a)$$

where

t = inside temperature near ceiling.
t_b = temperature in attic.
t_o = outside temperature.

If in the foregoing problem, involving the determination of the combined coefficient of transmission, the inside temperature t is 70 deg. fahr. and the outside temperature is −10 deg. fahr., the attic temperature, based on equation (10_a) will be:

$$t_b = \frac{70 \times 0.588 + 1.2 \times (-10) \times 0.605}{0.588 + 1.2 \times 0.605} = 26 \text{ deg. fahr.}$$

As previously stated, if the attic contains windows, ventilators, etc., the attic temperature will approach or equal the outside temperature, the roof will provide little or no resistance to the passage of heat, and the heat loss through the upper part of the building may be estimated by assuming the attic temperature to be the same as the outside temperature and using the heat transmission coefficient of the ceiling.

The heat loss through floors into basements and into unheated rooms kept closed may be computed by assuming a temperature for these rooms of 32 deg. fahr.

Areas Where Transmission Losses Occur

Heat is lost from a building by transmission through all of those surfaces which separate heated spaces from the outside air or from unheated colder spaces within the building. In general, five kinds of surfaces are involved: (1) outside walls; (2) outside glass; (3) inside walls or partitions next to unheated spaces; (4) ceilings of upper floors, either below a cold attic space or as the underside of a roof slab, and (5) floors of heated rooms above an unheated space. In most cases, only items (1) and (2), outside wall and glass surface, are considered. Failure to take account of the other heat-losing surfaces, items (3), (4) and (5), when they exist in a building, has generally resulted in more or less dissatisfaction with the operation of the heating plant, as a result of failure to heat the rooms having such surfaces as indicated by items (3), (4) and (5).

The net outside wall surface is usually determined by reference to the scale plans and elevations of the building concerned. In some cases, of course, the actual building may have to be measured. The total area of all outside openings which are occupied by windows and doors is accurately measured and listed as *glass*. The *glass* area is then deducted from the total outside wall area for each room and the difference is the net wall area. The outside wall areas for any floor should be based on the vertical floor-to-floor heights and the horizontal distance from center to center of partitions separating different rooms. If there are no partitions, measure from inside face of one wall to inside face of next wall. The areas of walls, ceilings and floors next to cold or unheated spaces are found, of course, by taking the inside dimensions of such areas, measured on the heated side.

Calculations for Transmission Losses

The calculations for heat transmission losses are made by multiplying the area A in square feet of wall, glass, roof or floor through which the loss takes place, by the proper coefficient U for such construction (Tables 12 to 36, or by computation as described under Transmission Coefficients by Computation) and by the temperature difference between the inside air temperature t at the proper level (in many cases not the *breathing line*) and the outside air temperature t_o. Therefore,

$$H_t = A\,U\,(t - t_o) \qquad (11)$$

where

H_t = B.t.u. per hour transmitted through the material of the wall, glass, roof or floor.

A = area in square feet of wall, glass, roof or floor, taken from building plans or actually measured. (Use the net inside or heated surface dimensions in all cases).

$t - t_o$ = temperature-difference between inside and outside air, in which t must always be taken at the proper level. Note that t may not be the *breathing-line* temperature in many cases.

Economic Value of Insulation

Fuel Saving: Any reduction in the heat losses through the walls and roof of a building, such as by the use of insulation, will reduce the amount of fuel required to heat the building.

The saving in coal resulting from the installation of a commercial insulation in the walls and/or roof of a building can be estimated by the following formula:

$$F_c = \frac{(U - U_i) \times N \times (t - t_a) \times A}{C_c \times E_c \times 2{,}000} \qquad (12)$$

where

F_c = saving in fuel in tons of coal per heating season.
U = coefficient of heat transfer of construction without insulation.
U_i = coefficient of heat transfer of construction with insulation.
N = number of hours during heating season.
t = inside temperature at proper level for wall or roof.
t_a = average outside temperature during heating season N.
A = net wall or roof area.
C_c = calorific value of coal.
E_c = overall efficiency of heating system.

To illustrate the use of this formula, suppose that the coefficient U of a certain factory roof without insulation is 0.25 and that the coefficient U_i of this roof with a given thickness of a certain type of insulation is 0.15. Let it also be assumed that the heating season is 210 days or 5,040 hours and that the average outside temperature t_a during this heating season is 35 deg. fahr. The roof area A is 10,000 sq. ft., the calorific value of the coal is 12,000 B.t.u. per pound, and the overall efficiency of the heating system is assumed to be 50 per cent. If the inside air temperature t is 75 deg. fahr. (at the roof in this case) and is maintained constantly during the heating season, the saving in fuel will be:

$$F_c = \frac{(0.25 - 0.15) \times 5{,}040 \times (75 - 35) \times 10{,}000}{12{,}000 \times 0.50 \times 2{,}000}$$

$$= 16.8 \text{ tons of coal per average heating season.}$$

If in the foregoing problem the building is heated intermittently, the fuel consumption and fuel saving will be reduced correspondingly, but not in direct proportion to the number of hours the heating plant is not in operation. Recent tests indicate that a saving in the fuel consumption of from 10 to 20 per cent will result by allowing the heat to be shut off after working hours and only heating the building to the required temperature during the period of occupancy each day. Hence, the fuel saving of 16.8 tons would probably be reduced about 15 per cent by shutting off the heat at night in which case, the net fuel saving would be 14.3 tons of coal per heating season.

If the applied cost of the insulation is 11 cents per square foot for the thickness involved in this case, and the cost of coal including the handling of it, and disposal of ashes is $10.00 per ton, the annual return on the investment will be $100 \times \frac{14.3 \times 10.00}{0.11 \times 10{,}000}$ or 13 per cent, neglecting insurance and depreciation.

Experiments recently conducted at the University of Illinois indicate that ceiling insulation increases the temperature head, thus offsetting the effect of the insulation to a slight degree, and changing the value of t in equation (12).

In the case of flat roofs, the change in temperature head is due solely to the slight increase in temperature of the air underneath the ceiling. In the case of pitched roofs with unheated attics, not only is the temperature underneath the ceiling higher, but the attic temperature is lower after the installation of the insulation, excepting where the attic contains windows, ventilators, etc., in which case the attic temperature will be practically the same in both instances, and will approach or equal the outside temperature. If the attic contains no windows, ventilators or wall surfaces, the attic temperature before and after the insulation is installed may be estimated by equation (10_a), assuming the temperature t under the ceiling to be the same in both cases. By using the combined coefficient of transmission of the roof, attic and top-floor ceiling (Table 35), then the change in temperature of the air in the attic space can be neglected, and only the increase in temperature under the ceiling need be taken into consideration.

To be strictly correct, this change in temperature head should be considered in figuring fuel saving problems, but in most cases this degree of accuracy is not warranted.

In the case of vertical walls, the temperature head will be the same before and after the insulation is installed.

If oil is the fuel burned the annual saving in gallons of oil can be estimated by the following formula:

$$F_o = \frac{(U - U_i) \times N \times (t - t_a) \times A}{C_o \times E_o \times W} \qquad (13)$$

where

F_o = saving in fuel in gallons of oil per heating season.
C_o = calorific value of oil.
E_o = overall efficiency of the heating system for an oil-fired furnace (usually taken as 60 per cent).
W = weight of oil per gallon, pounds.

The average value of the product of C_o and W is about 141,000 B.t.u. To obtain the fuel saving from formula (13) in terms of barrels of oil, divide the result by 42, the number of gallons of oil in a barrel.

If gas is the fuel burned, the annual saving in cubic feet of gas can be estimated by the following formula:

$$F_g = \frac{(U - U_i) \times N \times (t - t_a) \times A}{C_g \times E_g} \qquad (14)$$

where

F_g = annual fuel saving in cubic feet of gas.
C_g = calorific value of gas in B.t.u. per cubic foot (usually taken as 535 for manufactured gas and 1,000 for natural gas).
E_g = overall efficiency of the heating system for a gas-fired furnace (usually taken as 75 per cent).

It should be understood that the heating efficiencies of 50, 60 and 75 per cent, which are frequently used for estimating fuel savings with coal, oil and gas are approximate values and apply more specifically where the heating plant is not located in the building heated, and consequently, where there is no regain of the sensible heat of the flue gases, and where the pipe transmission losses may be considerable. Where the heating plant is located within the building to be heated, the *house* or *building* efficiencies for coal, oil and gas may be substantially higher than those specified, although it is even possible that the efficiencies may be lower than these values under varying conditions of operation.

Radiation Saving: The installation of a given thickness of insulation in the walls and/or roof of a building will reduce the amount of direct radiation required to maintain the desired temperature, and in many cases this may be an item of considerable importance; in fact, in the case of certain uninsulated constructions having a high rate of heat transmission, the monetary value of the saving in radiation due to the application of the insulation, may be sufficient to offset the cost of the insulation. The amount of radiation that can be saved is of course determined from the difference in the radiation requirements of the uninsulated and insulated buildings. The radiation saving can also be estimated by means of the following formula, if a steam heating system is to be installed:

$$R_s = \frac{(U - U_i) \times (t - t_o) \times A}{240} \qquad (15)$$

where

R_s = saving in square of equivalent radiation based on a steam heating system.

t_o = the outside temperature on which the design of the system is based.

If in the example on page 32, the temperature t_o is 0 deg. fahr., the saving in radiation for a steam heating system will be:

$$R_s = \frac{(0.25 - 0.15) \times (75 - 0) \times 10{,}000}{240}$$

$$= 312 \text{ sq. ft. of equivalent direct radiation.}$$

If the allowance on the reduction in the radiation required for this building on the above basis is $1.00 per square foot, the monetary value of the radiation saving will be $312.00, which if credited to the insulation, will leave a net cost of the insulation of $0.11 × 10,000 or $1,100.00 minus $312.00 or $788.00, and the annual return on the investment, taking both the fuel and radiation savings into consideration, will be $100 \times \frac{\$10.00 \times 14.3}{\$788.00}$ of 18.1 per cent, neglecting insurance and depreciation.

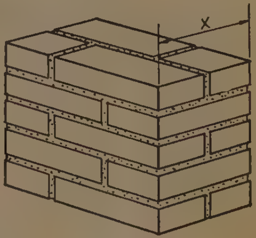
The radiation saving for a hot water or vapor system can be estimated by substituting the proper heat emission factor in the denominator of equation (15) for the value of 240 for steam. This heat emission factor varies with the heat dissipation coefficient of the radiator and the temperature difference between the medium in the radiator and the air surrounding it and is about 160 for hot water. However, it is obvious that the same factor should be used for estimating the radiation saving with insulation as was used for designing the heating system.

TABLE 12. COEFFICIENTS OF TRANSMISSION (U) OF SOLID BRICK WALLS[b]

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Brick	5.00 per 1"
Cement Mortar	8.00 per 1"
Plaster board	3.73 per ⅜"
Plaster (Gypsum)	2.32 per 1"
Wood Lath & Plaster	2.00 as applied
Cork board	0.30 per 1"
Rigid Insulation (Board form)	0.33 per 1"
Cellular Gypsum (18#)	0 59 per 1"
Flaked Gypsum, Dry (24#)	0.48 per 1"
Split Furring Tile	1½" = 1 40 2" = 1.25



Y = Thickness of Insulation where specified

Number	Interior Construction	Y	Thickness of Brick – X 8" A	12" B	16" C
1	Plain Walls – No Interior Finish		0.385	0.295	0.238
2	½" Plaster on Brick		0.356	0.277	0.227
3	¾" Plaster on Metal Lath – Furred		0.261	0.216	0.184
4	½" Plaster on Wood Lath – Furred		0.250	0.208	0.178
5	½" Plaster on ⅜" Plaster board – Furred		0.251	0.209	0.179
6	½" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill [c]	[a] 1⅝"	0.171	0.151	0.135
7	½" Plaster on Wood Lath on 2" Furring Strips – Flaked Gypsum Fill	[a] 1⅝"	0.154	0.137	0.124
8	½" Plaster on Rigid Insulation (Board form) Furred	½"	0.191	0.166	0.146
9		1"	0.148	0.132	0.120
10	½" Plaster on Corkboard set in ½" Cement Mortar	1½"	0.127	0.115	0.104
11		2"	0.105	0.097	0.090
12	½" Plaster on 1½" Split Furring Tile set against Wall		0.284	0.231	0.195
13	½" Plaster on 2" Split Furring Tile set against Wall		0.277	0.227	0.192

---

[a] Based on 1⅝ in., the actual thickness of 2 in. furring strips.

[b] The coefficients on this page can also be used with sufficient accuracy for the Ideal Rolok-Bak Wall.

[c] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

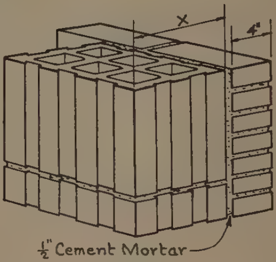
TABLE 13. COEFFICIENTS OF TRANSMISSION (U) OF BRICK VENEER ON HOLLOW TILE WALLS[c]

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Hollow Tile	6"=0.54 8"=0.49 10"=0.46 12"=0.33
Brick	5.00 per 1"
Cement Mortar	8.00 per 1"
Plasterboard	3.73 per $\frac{3}{8}$"
Plaster (Gypsum)	2.32 per 1"
Wood Lath & Plaster	2.00 as applied
Corkboard	0.30 per 1"
Rigid Insulation (Board form)	0.33 per 1"
Cellular Gypsum (18#)	0.59 per 1"
Flaked Gypsum, Dry (24#)	0.48 per 1"

Y = Thickness of Insulation where specified



Number	Interior Construction	Y	Thickness of Hollow Tile – X			
			6"	8"	10"	12"
			A	B	C	D
1	Plain Walls – No Interior Finish		0.270	0.257	0.248	0.205
2	$\frac{1}{2}$" Plaster on Hollow Tile		0.254	0.243	0.235	0.196
3	$\frac{3}{4}$" Plaster on Metal Lath – Furred		0.202	0.195	0.190	0.163
4	$\frac{1}{2}$" Plaster on Wood Lath – Furred		0.195	0.188	0.184	0.159
5	$\frac{1}{2}$" Plaster on $\frac{3}{8}$" Plaster board – Furred		0.198	0.189	0.185	0.159
6	$\frac{1}{2}$" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill [b]	[a] $1\frac{5}{8}$"	0.144	0.140	0.137	0.123
7	$\frac{1}{2}$" Plaster on Wood Lath on 2" Furring Strips – Flaked Gypsum Fill	[a] $1\frac{5}{8}$"	0.131	0.128	0.126	0.114
8	$\frac{1}{2}$" Plaster on Rigid Insulation – (Board form) Furred	$\frac{1}{2}$"	0.158	0.153	0.150	0.133
9		1"	0.127	0.124	0.122	0.110
10	$\frac{1}{2}$" Plaster on Corkboard set in $\frac{1}{2}$" Cement Mortar	$1\frac{1}{2}$"	0.112	0.110	0.107	0.098
11		2"	0.094	0.092	0.091	0.085

[a] Based on 1⅝ in., the actual thickness of 2 in. furring strips.

[b] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

[c] The 6 in., 8 in. and 10 in. tile figures are based on two cells in the direction of flow of heat. The 12 in. tile is based on three cells in the direction of flow of heat.

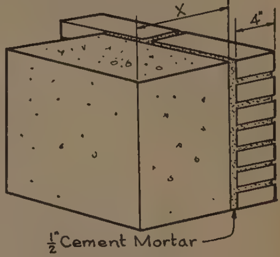
Table 14. Coefficients of Transmission (*U*) of Brick Veneer on Concrete Walls

Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. Fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Material	Conductivity
Concrete (Stone 1:2:4 mix)	8.30 per 1"
Brick	5.00 per 1"
Cement Mortar	8.00 per 1"
Plaster board	3.73 per ⅜"
Plaster (Gypsum)	2.32 per 1"
Wood Lath & Plaster	2.00 as applied
Corkboard	0.30 per 1"
Rigid Insulation (Board form)	0.33 per 1"
Cellular Gypsum (18#)	0.59 per 1"
Flaked Gypsum, Dry (24#)	0.48 per 1"

Y = Thickness of Insulation where specified



Number	Interior Construction	Y	Thickness of Concrete — X				
			6"	8"	10"	12"	16"
			A	B	C	D	E
1	Plain Walls — No Interior Finish		0.387	0.355	0.327	0.303	0.264
2	½" Plaster on Concrete		0.358	0.330	0.305	0.285	0.250
3	¾" Plaster on Metal Lath — Furred		0.263	0.247	0.233	0.221	0.200
4	½" Plaster on Wood Lath — Furred		0.250	0.237	0.224	0.213	0.192
5	½" Plaster on ⅜" Plaster board — Furred		0.252	0.238	0.225	0.213	0.192
6	½" Plaster on Wood Lath on 2" Furring Strips — Cellular Gypsum Fill [b]	1⅝" [a]	0.172	0.165	0.158	0.152	0.142
7	½" Plaster on Wood Lath on 2" Furring Strips — Flaked Gypsum Fill	1⅝" [a]	0.154	0.149	0.144	0.139	0.130
8	½" Plaster on Rigid Insulation — (Board form) Furred	½"	0.192	0.183	0.175	0.168	0.156
9		1"	0.148	0.143	0.139	0.134	0.126
10	½" Plaster on Cork board set in ½" Cement Mortar	1½"	0.127	0.123	0.120	0.116	0.110
11		2"	0.105	0.102	0.100	0.098	0.093

[a] Based on 1⅝ in., the actual thickness of 2 in. furring strips.

[b] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

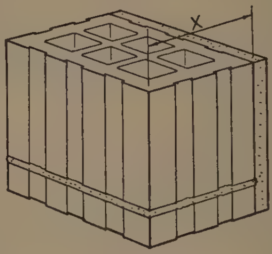
TABLE 15. COEFFICIENTS OF TRANSMISSION (U) OF HOLLOW TILE WALLS WITH STUCCO EXTERIOR FINISH [b-d]

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr per Sq. Ft. per 1°F

Stucco	8.00 per 1"
Hollow Tile	8" = 0.49 10" = 0.46 12" = 0.33 16" = 0.25
Cement Mortar	8.00 per 1"
Plaster board	3.73 per 3/8"
Plaster (Gypsum)	2.32 per 1"
Wood Lath & Plaster	2.00 as applied
Cork board	0.30 per 1"
Rigid Insulation (Board form)	0.33 per 1"
Cellular Gypsum (18#)	0.59 per 1"
Flaked Gypsum, Dry (24#)	0.48 per 1"

Y = Thickness of Insulation where specified



Number	Interior Construction	Y	Thickness of Hollow Tile – X 8" A	10" B	12" C	16" D
1	Plain Walls – No Interior Finish		0.317	0.304	0.241	0.195
2	1/2" Plaster on Hollow Tile		0.296	0.285	0.229	0.188
3	3/4" Plaster on Metal Lath – Furred		0.228	0.221	0.186	0.158
4	1/2" Plaster on Wood Lath – Furred		0.219	0.213	0.180	0.153
5	1/2" Plaster on 3/8" Plaster board – Furred		0.220	0.213	0.180	0.153
6	1/2" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill [c]	1 5/8" [a]	0.156	0.153	0.135	0.120
7	1/2" Plaster on Wood Lath on 2" Furring Strips – Flaked Gypsum Fill	1 5/8" [a]	0.141	0.139	0.124	0.111
8	1/2" Plaster on Rigid Insulation – (Board form) Furred	1/2"	0.172	0.168	0.147	0.129
9		1"	0.137	0.134	0.120	0.108
10	1/2" Plaster on Cork board set in 1/2" Cement Mortar	1 1/2"	0.119	0.117	0.106	0.096
11		2"	0.099	0.098	0.090	0.083

[a] Based on 1⅝ in., the actual thickness of 2 in. furring strips.

[b] Figures on this page can be used with sufficient accuracy for hollow tile walls without stucco finish.

[c] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

[d] The 8 in. and 10 in. tile figures are based on two cells in the direction of heat flow. The 12 in. tile is based on three cells in the direction of heat flow. The 16 in. tile consists of one 10 in. tile and one 6 in. tile, each having two cells in the direction of heat flow.

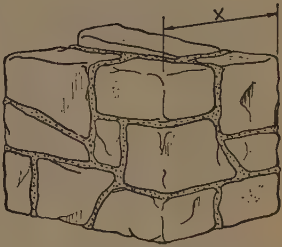
Table 16. Coefficients of Transmission (U) of Limestone or Sandstone Walls

Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. Fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Stone	10.00	per 1"
Cement Mortar	8.00	per 1"
Plaster board	3.73	per ⅜"
Plaster (Gypsum)	2.32	per 1"
Wood Lath & Plaster	2.00	as applied
Cork board	0.30	per 1"
Rigid Insulation (Board form)	0.33	per 1"
Cellular Gypsum (18*)	0.59	per 1"
Flaked Gypsum, Dry (24*)	0.48	per 1"

Y- Thickness of Insulation where specified



Number	Interior Construction	Y	Thickness of Stone – X 8" A	10" B	12" C	16" D	20" E	24" F
1	Plain Walls – No Interior Finish		0.556	0.502	0.457	0.385	0.334	0.295
2	½" Plaster on Stone		0.497	0.452	0.415	0.356	0.311	0.277
3	¾" Plaster on Metal Lath – Furred		0.330	0.310	0.292	0.261	0.236	0.216
4	½" Plaster on Wood Lath – Furred		0.312	0.294	0.277	0.250	0.227	0.208
5	½" Plaster on ⅜" Plaster board – Furred		0.314	0.295	0.279	0.251	0.228	0.209
6	½" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill [b]	[a] 1⅝"	0.198	0.191	0.184	0.171	0.160	0.150
7	½" Plaster on Wood Lath on 2" Furring Strips – Flaked Gypsum Fill	[a] 1⅝"	0.175	0.169	0.163	0.153	0.145	0.137
8	½" Plaster on Rigid Insulation (Board form) Furred	½"	0.225	0.216	0.207	0.191	0.177	0.166
9		1"	0.168	0.163	0.157	0.148	0.140	0.132
10	½" Plaster on Cork board set in ½" Cement Mortar	1½"	0.141	0.138	0.134	0.127	0.121	0.115
11		2"	0.114	0.112	0.109	0.105	0.101	0.098

[a] Based on 1⅝ in., the actual thickness of 2 in. furring strips.

[b] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

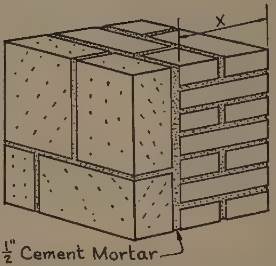
TABLE 17. COEFFICIENTS OF TRANSMISSION (U) OF 4-IN. CUT STONE VENEER ON BRICK WALLS

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Stone	10.00 per 1"
Brick	5.00 per 1"
Cement Mortar	8.00 per 1"
Plaster board	3.73 per $\frac{3}{8}$"
Plaster (Gypsum)	2.32 per 1"
Wood Lath & Plaster	2.00 as applied
Cork board	0.30 per 1"
Rigid Insulation (Board form)	0.33 per 1"
Cellular Gypsum (18#)	0.59 per 1"
Flaked Gypsum, Dry (24#)	0.48 per 1"

Y = Thickness of Insulation where specified



Number	Interior Construction	Y	Thickness of Brick – X		
			8"	12"	16"
			A	B	C
1	Plain Walls – No Interior Finish		0.326	0.259	0.215
2	$\frac{1}{2}$" Plaster on Brick		0.306	0.246	0.205
3	$\frac{3}{4}$" Plaster on Metal Lath – Furred		0.233	0.196	0.170
4	$\frac{1}{2}$" Plaster on Wood Lath – Furred		0.224	0.190	0.165
5	$\frac{1}{2}$" Plaster on $\frac{3}{8}$" Plasterboard – Furred		0.225	0.190	0.165
6	$\frac{1}{2}$" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill [b]	[a] $1\frac{5}{8}$"	0.158	0.141	0.126
7	$\frac{1}{2}$" Plaster on Wood Lath on 2" Furring Strips – Flaked Gypsum Fill	[a] $1\frac{5}{8}$"	0.143	0.128	0.117
8	$\frac{1}{2}$" Plaster on Rigid Insulation – (Board form) Furred	$\frac{1}{2}$"	0.175	0.154	0.137
9		1"	0.139	0.125	0.113
10	$\frac{1}{2}$" Plaster on Cork board set in $\frac{1}{2}$" Cement Mortar	$1\frac{1}{2}$"	0.120	0.110	0.100
11		2"	0.100	0.093	0.086

---

[a] Based on 1⅝ in., the actual thickness of 2 in. furring strips.

[b] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

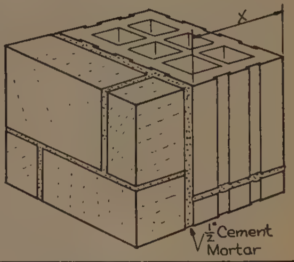
TABLE 18. COEFFICIENTS OF TRANSMISSION (U) OF 4-IN. CUT STONE VENEER ON HOLLOW TILE WALLS

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Hollow Tile	6"=0.54 8"=0.49 10"=0.46 12"=0.33
Stone	10.00 per 1"
Cement Mortar	8.00 per 1"
Plasterboard	3.73 per 3/8"
Plaster (Gypsum)	2.32 per 1"
Wood Lath & Plaster	2.00 as applied
Corkboard	0.30 per 1"
Rigid Insulation (Board form)	0.33 per 1"
Cellular Gypsum (18#)	0.59 per 1"
Flaked Gypsum, Dry (24#)	0.48 per 1"

Y = Thickness of Insulation where specified



Number	Interior Construction	Y	Thickness of Hollow Tile — X[c] 6" A	8" B	10" C	12" D
1	Plain Walls – No Interior Finish		0.302	0.286	0.276	0.223
2	1/2" Plaster on Hollow Tile		0.283	0.270	0.260	0.213
3	3/4" Plaster on Metal Lath – Furred		0.220	0.211	0.206	0.175
4	1/2" Plaster on Wood Lath – Furred		0.212	0.204	0.199	0.170
5	1/2" Plaster on 3/8" Plasterboard – Furred		0.212	0.204	0.199	0.170
6	1/2" Plaster on Wood Lath on 2" Furring Strips — Cellular Gypsum Fill[b]	1 5/8"[a]	0.152	0.148	0.145	0.129
7	1/2" Plaster on Wood Lath on 2" Furring Strips — Flaked Gypsum Fill	1 5/8"[a]	0.138	0.135	0.132	0.119
8	1/2" Plaster on Rigid Insulation — (Board form) Furred	1/2"	0.168	0.163	0.159	0.140
9		1"	0.134	0.131	0.128	0.115
10	1/2" Plaster on Corkboard set in 1/2" Cement Mortar	1 1/2"	0.116	0.114	0.112	0.102
11		2"	0.097	0.096	0.095	0.088

[a] Based on 1⅝ in., the actual thickness of 2 in. furring strips.

[b] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

[c] The 6 in., 8 in. and 10 in. tile figures are based on two cells in the direction of heat flow. The 12 in. tile is based on three cells in the direction of heat flow.

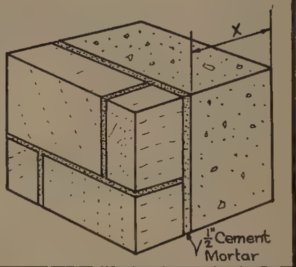
Table 19. Coefficients of Transmission (*U*) of 4-in. Cut Stone Veneer on Concrete Walls

Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. Fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Stone	10.00 per 1"
Concrete (Stone 1:2:4 mix)	8.30 per 1"
Cement Mortar	8.00 per 1"
Plaster board	3.73 per 3/8"
Plaster (Gypsum)	2.32 per 1"
Wood Lath & Plaster	2.00 as applied
Corkboard	0.30 per 1"
Rigid Insulation (Board form)	0.33 per 1"
Cellular Gypsum (18#)	0.59 per 1"
Flaked Gypsum, Dry (24#)	0.48 per 1"

Y = Thickness of Insulation where specified



Number	Interior Construction	Y	Thickness of Concrete —X 6" A	8" B	10" C	12" D	16" E
1	Plain Walls – No Interior Finish		0.459	0.413	0.377	0.345	0.296
2	1/2" Plaster on Concrete		0.418	0.380	0.348	0.321	0.279
3	3/4" Plaster on Metal Lath – Furred		0.293	0.274	0.257	0.242	0.217
4	1/2" Plaster on Wood Lath – Furred		0.279	0.261	0.246	0.232	0.209
5	1/2" Plaster on 3/8" Plaster board – Furred		0.280	0.262	0.247	0.233	0.209
6	1/2" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill [b]	1 5/8" [a]	0.184	0.176	0.169	0.163	0.151
7	1/2" Plaster on Wood Lath on 2" Furring Strips – Flaked Gypsum Fill	1 5/8" [a]	0.164	0.158	0.152	0.147	0.137
8	1/2" Plaster on Rigid Insulation – (Board form) Furred	1/2"	0.208	0.198	0.188	0.180	0.166
9		1"	0.158	0.152	0.147	0.142	0.133
10	1/2" Plaster on Corkboard set in 1/2" Cement Mortar	1 1/2"	0.134	0.130	0.126	0.122	0.116
11		2"	0.110	0.107	0.104	0.102	0.097

[a] Based on 1⅝ in., the actual thickness of 2 in. furring strips.

[b] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

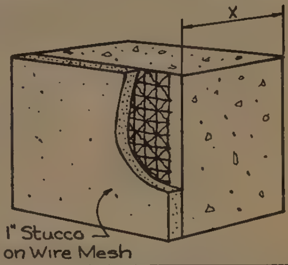
TABLE 20. COEFFICIENTS OF TRANSMISSION (U) OF CONCRETE WALLS WITH STUCCO AS EXTERIOR FINISH

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1° F

Stucco	8.00 per 1"
Concrete (Stone 1:2:4 mix)	8.30 per 1"
Plaster board	3.73 per ⅜"
Plaster (Gypsum)	2.32 per 1"
Wood Lath & Plaster	2.00 as applied
Cork board	0.30 per 1"
Rigid Insulation (Board form)	0.33 per 1"
Cellular Gypsum (18#)	0.59 per 1"
Flaked Gypsum, Dry (24#)	0.48 per 1"

Y = Thickness of Insulation where specified



Number	Interior Construction	Y	Thickness of Concrete – X					
			6"	8"	10"	12"	16"	20"
			A	B	C	D	E	F
1	Plain Walls – No Interior Finish		0.544	0.481	0.431	0.391	0.329	0.284
2	½" Plaster on Concrete		0.486	0.437	0.395	0.361	0.308	0.268
3	¾" Plaster on Metal Lath – Furred		0.326	0.302	0.282	0.264	0.234	0.210
4	½" Plaster on Wood Lath – Furred		0.308	0.287	0.268	0.252	0.225	0.203
5	½" Plaster on ⅜" Plaster board – Furred		0.310	0.288	0.270	0.253	0.226	0.204
6	½" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill [b]	[a] 1⅝"	0.196	0.188	0.179	0.172	0.159	0.148
7	½" Plaster on Wood Lath on 2" Furring Strips – Flaked Gypsum Fill	[a] 1⅝"	0.173	0.167	0.161	0.154	0.144	0.135
8	½" Plaster on Rigid Insulation (Board form) Furred	½"	0.223	0.212	0.202	0.192	0.176	0.163
9		1"	0.167	0.160	0.154	0.149	0.139	0.130
10	½" Plaster on Corkboard set in ½" Cement Mortar	1½"	0.141	0.136	0.132	0.127	0.120	0.114
11		2"	0.114	0.111	0.108	0.105	0.100	0.096

[a] Based on 1⅝ in., the actual thickness of 2 in. furring strips.

[b] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

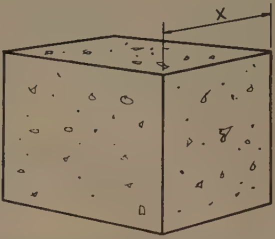
Table 21. Coefficients of Transmission (U) of Concrete Walls with No Exterior Finish

Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Concrete (Stone 1:2:4 mix)	8.30 per 1"
Plasterboard	3.73 per ⅜"
Plaster (Gypsum)	2.32 per 1"
Wood Lath & Plaster	2.00 as applied
Cork board	0.30 per 1"
Rigid Insulation (Board form)	0.33 per 1"
Cellular Gypsum (18*)	0.59 per 1"
Flaked Gypsum, Dry (24*)	0.48 per 1"

Y = Thickness of Insulation where specified



Number	Interior Construction	Y	Thickness of Concrete – X					
			6"	8"	10"	12"	16"	20"
			A	B	C	D	E	F
1	Plain Walls – No Interior Finish		0.583	0.512	0.455	0.411	0.343	0.294
2	½" Plaster on Concrete		0.518	0.461	0.416	0.378	0.320	0.277
3	¾" Plaster on Metal Lath – Furred		0.339	0.314	0.292	0.273	0.241	0.216
4	½" Plaster on Wood Lath – Furred		0.320	0.297	0.277	0.260	0.231	0.208
5	½" Plaster on ⅜" Plaster board – Furred		0.322	0.299	0.279	0.261	0.232	0.209
6	½" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill [b]	[a] 1⅝"	0.202	0.192	0.183	0.176	0.162	0.151
7	½" Plaster on Wood Lath on 2" Furring Strips – Flaked Gypsum Fill	[a] 1⅝"	0.177	0.170	0.163	0.157	0.146	0.137
8	½" Plaster on Rigid Insulation (Board form) Furred	½"	0.229	0.217	0.207	0.197	0.180	0.166
9		1"	0.170	0.164	0.157	0.152	0.141	0.132
10	½" Plaster on Corkboard set in ½" Cement Mortar	1½"	0.142	0.138	0.134	0.131	0.122	0.116
11		2"	0.116	0.113	0.109	0.106	0.101	0.097

[a] Based on 1⅝ in., the actual thickness of 2 in. furring strips.

[b] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

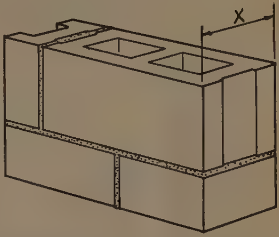
TABLE 22. COEFFICIENTS OF TRANSMISSION (U) OF CINDER AND CONCRETE BLOCK WALLS[b-d]

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Cinder Blocks	8"=0.45	12"=0.28
Concrete Blocks	8"=0.84	12"=0.52
Cement Mortar		8.00 per 1"
Plaster board		3.73 per ⅜"
Plaster (Gypsum)		2.32 per 1"
Wood Lath & Plaster		2.00 as applied
Cork board		0.30 per 1"
Rigid Insulation (Board form)		0.33 per 1"
Cellular Gypsum (18*)		0.59 per 1"
Flaked Gypsum, Dry (24*)		0.48 per 1"

Y = Thickness of Insulation where specified



Number	Interior Construction	Y	Thickness – X and Kind of Blocks			
			8" Cinder	8" Concrete	12" Cinder	12" Concrete
			A	B	C	D
1	Plain Walls – No Interior Finish		0.311	0.458	0.219	0.343
2	½" Plaster on Blocks		0.291	0.416	0.209	0.319
3	¾" Plaster on Metal Lath – Furred		0.225	0.293	0.173	0.241
4	½" Plaster on Wood Lath – Furred		0.216	0.278	0.167	0.231
5	½" Plaster on ⅜" Plaster board – Furred		0.217	0.280	0.168	0.232
6	½" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill [c]	1⅝"[a]	0.155	0.184	0.128	0.162
7	½" Plaster on Wood Lath on 2" Furring Strips – Flaked Gypsum Fill	1⅝"[a]	0.140	0.163	0.118	0.146
8	½" Plaster on Rigid Insulation – (Board form) Furred	½"	0.171	0.207	0.139	0.180
9		1"	0.136	0.158	0.114	0.141
10	½" Plaster on Cork board set in ½" Cement Mortar	1½"	0.118	0.134	0.102	0.122
11		2"	0.098	0.109	0.087	0.101

[a] Based on 1⅝ in., the actual thickness of 2 in. furring strips.

[b] The figures on this page may be used with sufficient accuracy for cinder and concrete block walls with stucco exterior finish.

[c] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

[d] The form of the 8 in. blocks on which the figures in this table are based is shown in the above sketch. The 12 in. blocks are based on two air cells through the block instead of one.

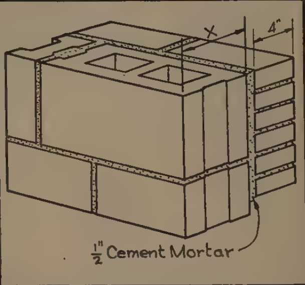
Table 23. Coefficients of Transmission (U) of Brick Veneer on Cinder and Concrete Block Walls[c]

Note.—These coefficients are expressed in B.t.u. per hour per square foot per 1 deg. Fahr. difference in temperature between the air on the two sides and are based on an outside wind exposure of 15 miles per hour.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Cinder Blocks	8"=0.45	12"=0.28
Concrete Blocks	8"=0.84	12"=0.52
Brick		5.00 per 1"
Cement Mortar		8.00 per 1"
Plaster board		3.73 per 3/8"
Plaster (Gypsum)		2.32 per 1"
Wood Lath & Plaster		2.00 as applied
Corkboard		0.30 per 1"
Rigid Insulation (Board form)		0.33 per 1"
Cellular Gypsum (18#)		0.59 per 1"
Flaked Gypsum, Dry (24#)		0.48 per 1"

Y = Thickness of Insulation where specified



Number	Interior Construction	Y	8" Cinder A	8" Concrete B	12" Cinder C	12" Concrete D
1	Plain Walls – No Interior Finish		0.245	0.328	0.184	0.264
2	1/2" Plaster on Blocks		0.233	0.306	0.177	0.250
3	3/4" Plaster on Metal Lath – Furred		0.188	0.234	0.150	0.199
4	1/2" Plaster on Wood Lath – Furred		0.182	0.224	0.146	0.192
5	1/2" Plaster on 3/8" Plaster board – Furred		0.183	0.225	0.147	0.193
6	1/2" Plaster on Wood Lath on 2" Furring Strips – Cellular Gypsum Fill[b]	[a] 1 5/8"	0.136	0.158	0.115	0.142
7	1/2" Plaster on Wood Lath on 2" Furring Strips – Flaked Gypsum Fill	[a] 1 5/8"	0.125	0.144	0.107	0.130
8	1/2" Plaster on Rigid Insulation – (Board form) Furred	1/2"	0.149	0.176	0.124	0.156
9		1"	0.121	0.139	0.104	0.126
10	1/2" Plaster on Corkboard set in 1/2" Cement Mortar	1 1/2"	0.107	0.120	0.093	0.110
11		2"	0.090	0.100	0.081	0.093

[a] Based on 1⅝ in., the actual thickness of 2 in. furring strips.

[b] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

[c] The form of the 8 in. blocks on which the figures in this table are based is shown in the above sketch. The 12 in. blocks are based on two air cells through the block instead of one.

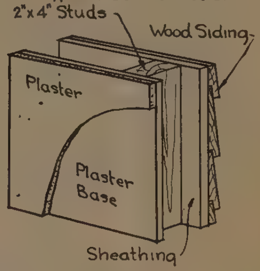
TABLE 24. COEFFICIENTS OF TRANSMISSION (*U*) OF WOOD SIDING OR CLAPBOARD FRAME WALLS

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1° F

Wood (Yellow Pine or Fir)		1.00 per 1"
Plaster (Gypsum)		2.32 per 1"
Plaster board	3.73 per ⅜"	2.80 per ½"
Cork board		0.30 per 1"
Wood Lath & Plaster		2.00 as applied
Rigid Insulation (Board form)		0.33 per 1"
Flexible Insulation		0.27 per 1"
Cellular Gypsum (18*)		0.59 per 1"
Flaked Gypsum (24*)		0.48 per 1"

Typical Construction



Number	Type of Sheathing	Insulation between Studding	Plaster Base: Wood Lath	Metal Lath	⅜" Plaster-board	½" Rigid Insulation	1" Rigid Insulation	1½" Cork-board	2" Cork-board
			A	B	C	D	E	F	G
1	1" Wood [b]	None	0.262	0.275	0.263	0.198	0.153	0.117	0.098
2		Flaked Gypsum Fill (24*) [a]	0.096	0.098	0.096	0.086	0.076	0.067	0.060
3		Cellular Gypsum Fill (18*) [a–c]	0.111	0.113	0.111	0.097	0.085	0.073	0.065
4		½" Flexible Insulation	0.152	0.157	0.153	0.128	0.107	0.089	0.077
5	½" Rigid Insulation (Board form)	None	0.220	0.229	0.221	0.173	0.137	0.108	0.092
6		Flaked Gypsum Fill (24*) [a]	0.090	0.091	0.090	0.081	0.072	0.063	0.058
7		Cellular Gypsum Fill (18*) [a–c]	0.102	0.104	0.103	0.090	0.080	0.069	0.062
8		½" Flexible Insulation	0.137	0.140	0.137	0.117	0.099	0.083	0.073
9	½" Plaster-board	None	0.295	0.312	0.297	0.216	0.163	0.123	0.102
10		Flaked Gypsum Fill (24*) [a]	0.099	0.102	0.100	0.089	0.079	0.068	0.062
11		Cellular Gypsum Fill (18*) [a–c]	0.116	0.118	0.116	0.102	0.088	0.075	0.067
12		½" Flexible Insulation	0.163	0.167	0.163	0.135	0.112	0.092	0.080

[a] Thickness of fill assumed 3⅝ in., based on 2 in. by 4 in. studding.

[b] Based on $^{25}/_{32}$ in., the actual thickness of 1 in. or ⅞ in. sheathing. Building paper neglected.

[c] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

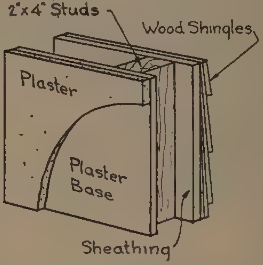
TABLE 25. COEFFICIENTS OF TRANSMISSION (U) OF WOOD SHINGLE FRAME WALLS

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Wood (Yellow Pine or Fir)	1.00 per 1"
Plaster (Gypsum)	2.32 per 1"
Plaster board 3.73 per 3/8"	2.80 per 1/2"
Cork board	0.30 per 1"
Wood Lath & Plaster	2.00 as applied
Rigid Insulation (Board form)	0.33 per 1"
Flexible Insulation	0.27 per 1"
Cellular Gypsum (18*)	0.59 per 1"
Flaked Gypsum (24*)	0.48 per 1"

Typical Construction



Number	Type of Sheathing	Insulation between Studding	Plaster Base: Wood Lath A	Metal Lath B	3/8" Plaster-board C	1/2" Rigid Insulation D	1" Rigid Insulation E	1½" Cork-board F	2" Cork-board G
1	1" Wood [c]	None	0.262	0.275	0.263	0.198	0.153	0.117	0.098
2		Flaked Gypsum Fill (24*) [a]	0.096	0.098	0.096	0.086	0.076	0.067	0.060
3		Cellular Gypsum Fill (18*) [a-d]	0.111	0.113	0.111	0.097	0.085	0.073	0.065
4		1/2" Flexible Insulation	0.152	0.157	0.153	0.128	0.107	0.089	0.077
5	1/2" Rigid Insulation (Board form) [b]	None	0.183	0.190	0.184	0.150	0.122	0.098	0.085
6		Flaked Gypsum Fill (24*) [a]	0.083	0.084	0.083	0.076	0.068	0.060	0.055
7		Cellular Gypsum Fill (18*) [a-d]	0.094	0.095	0.094	0.084	0.075	0.065	0.059
8		1/2" Flexible Insulation	0.122	0.125	0.122	0.106	0.091	0.077	0.069
9	1/2" Plaster-board [b]	None	0.233	0.243	0.234	0.181	0.142	0.111	0.094
10		Flaked Gypsum Fill (24*) [a]	0.091	0.093	0.092	0.083	0.074	0.065	0.059
11		Cellular Gypsum Fill (18*) [a-d]	0.105	0.107	0.105	0.093	0.081	0.070	0.063
12		1/2" Flexible Insulation	0.142	0.146	0.142	0.121	0.102	0.085	0.074

[a] Thickness of fill assumed 3⅝ in., based on 2 in. by 4 in. studding.

[b] Furring strips between wood shingles and sheathing.

[c] Based on 25/32 in., the actual thickness of 1 in. or ⅞ in. sheathing. Building paper neglected.

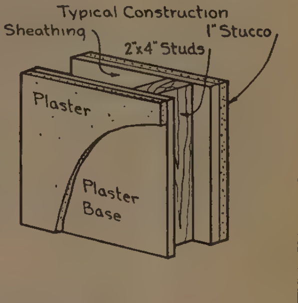
[d] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

TABLE 26. COEFFICIENTS OF TRANSMISSION (U) OF STUCCO FRAME WALLS

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1° F

Wood (Yellow Pine or Fir)	1.00 per 1"
Plaster (Gypsum)	2.32 per 1"
Plaster board	3.73 per ⅜" 2.80 per ½"
Cork board	0.30 per 1"
Wood Lath & Plaster	2.00 as applied
Rigid Insulation (Board form)	0.33 per 1"
Flexible Insulation	0.27 per 1"
Cellular Gypsum (18#)	0.59 per 1"
Flaked Gypsum (24#)	0.48 per 1"
Brick	5.00 per 1"
Stucco	8.00 per 1"



Number	Type of Sheathing	Insulation between Studding	Plaster Base						
			Wood Lath	Metal Lath	⅜" Plaster-board	½" Rigid Insulation	1" Rigid Insulation	1½" Cork-board	2" Cork-board
			A	B	C	D	E	F	G
1	1" Wood[b]	None	0.302	0.319	0.304	0.220	0.165	0.125	0.103
2		Flaked Gypsum Fill (24#)[a]	0.101	0.102	0.101	0.089	0.079	0.068	0.061
3		Cellular Gypsum Fill (18#)[a-c]	0.117	0.120	0.117	0.103	0.089	0.075	0.067
4		½" Flexible Insulation	0.165	0.169	0.165	0.137	0.113	0.093	0.080
5	½" Rigid Insulation (Board form)	None	0.247	0.259	0.248	0.190	0.147	0.114	0.096
6		Flaked Gypsum Fill (24#)[a]	0.094	0.095	0.094	0.084	0.075	0.065	0.058
7		Cellular Gypsum Fill (18#)[a-c]	0.108	0.110	0.108	0.095	0.083	0.072	0.064
8		½" Flexible Insulation	0.147	0.151	0.147	0.125	0.105	0.087	0.076
9	½" Plaster-board	None	0.347	0.369	0.349	0.243	0.178	0.131	0.108
10		Flaked Gypsum Fill (24#)[a]	0.105	0.107	0.105	0.093	0.081	0.070	0.063
11		Cellular Gypsum Fill (18#)[a-c]	0.123	0.126	0.124	0.107	0.092	0.078	0.069
12		½" Flexible Insulation	0.177	0.183	0.178	0.146	0.119	0.097	0.083

[a] Thickness of fill assumed 3⅝ in., based on 2 in. by 4 in. studding.

[b] Based on 25/32 in., the actual thickness of 1 in. or ⅞ in. sheathing. Building paper neglected.

[c] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

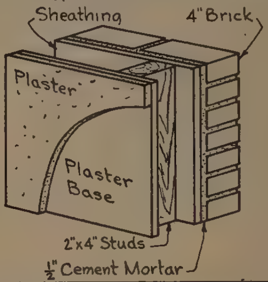
TABLE 27. COEFFICIENTS OF TRANSMISSION (U) OF BRICK VENEER FRAME WALLS

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Wood (Yellow Pine or Fir)		1.00 per 1"
Plaster (Gypsum)		2.32 per 1"
Plaster board	3.73 per ⅜"	2.80 per ½"
Cork board		0.30 per 1"
Wood Lath & Plaster		2.00 as applied
Rigid Insulation (Board form)		0.33 per 1"
Flexible Insulation		0.27 per 1"
Cellular Gypsum (18*)		0.59 per 1"
Flaked Gypsum (24*)		0.48 per 1"
Brick		5.00 per 1"

Typical Construction



Number	Type of Sheathing	Insulation between Studding	Plaster Base						
			Wood Lath	Metal Lath	⅜" Plaster board	½" Rigid Insula-tion	1" Rigid Insula-tion	1½" Cork board	2" Cork board
			A	B	C	D	E	F	G
1	1" Wood [b]	None	0.247	0.258	0.248	0.189	0.147	0.114	0.087
2		Flaked Gypsum Fill (24*) [a]	0.094	0.095	0.094	0.084	0.075	0.065	0.058
3		Cellular Gypsum Fill (18*) [a-c]	0.108	0.110	0.108	0.095	0.083	0.072	0.064
4		½" Flexible Insulation	0.147	0.150	0.147	0.125	0.105	0.087	0.076
5	½" Rigid Insulation (Board form)	None	0.209	0.217	0.210	0.166	0.133	0.106	0.090
6		Flaked Gypsum Fill (24*) [a]	0.087	0.089	0.087	0.079	0.071	0.062	0.056
7		Cellular Gypsum Fill (18*) [a-c]	0.100	0.102	0.101	0.089	0.079	0.068	0.061
8		½" Flexible Insulation	0.133	0.136	0.133	0.114	0.098	0.082	0.072
9	½" Plaster board	None	0.276	0.290	0.277	0.206	0.157	0.120	0.100
10		Flaked Gypsum Fill (24*) [a]	0.098	0.100	0.098	0.087	0.077	0.067	0.060
11		Cellular Gypsum Fill (18*) [a-c]	0.113	0.115	0.113	0.100	0.086	0.074	0.066
12		½" Flexible Insulation	0.157	0.161	0.157	0.131	0.109	0.090	0.079

[a] Thickness of fill assumed 3⅝ in., based on 2 in. by 4 in. studding.

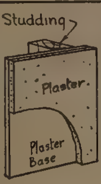
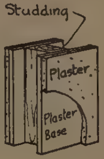
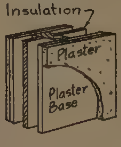
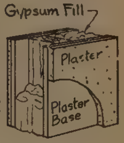
[b] Based on 25/32 in., the actual thickness of 1 in. or ⅞ in. sheathing. Building paper neglected

[c] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

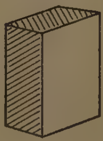
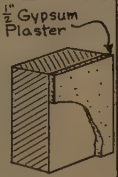
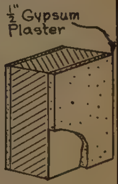
TABLE 28. COEFFICIENTS OF TRANSMISSION (U) OF INTERIOR WALLS AND PARTITIONS

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON STILL-AIR (NO WIND) CONDITIONS ON BOTH SIDES.

PLASTERED FRAME PARTITIONS

	The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F Plaster (Gypsum) 2.32 per 1" Plaster board 3.73 per ⅜" Wood Lath & Plaster 2.00 as appld Rigid Insulation (Board form) 0.33 per 1" Flexible Insulation 0.27 per 1" Corkboard 0.30 per 1" Cellular Gypsum (18#) 0.59 per 1" Flaked Gypsum, Dry (24#) 0.48 per 1"	On one side of Studding only	On both sides of Studding	Insulation between Studding		Gypsum Fill between Studding	
							
				½" Rigid Insulation (Board form)	½" Flexible Insulation	Cellular Gypsum Fill [a-d]	Flaked Gypsum Fill [a]
No.	Plaster Base	A	B	C	D	E	F
1	Metal Lath[b]	0.551	0.328	0.183	0.173	0.121	0.103
2	Wood Lath[c]	0.502	0.294	0.172	0.162	0.116	0.100
3	⅜" Plaster board[c]	0.506	0.297	0.172	0.163	0.117	0.100
4	½" Rigid Insulation (Board form)[c]	0.310	0.170	0.121	0.116	0.090	0.080
5	1" Rigid Insulation (Board form)[c]	0.211	0.113	0.088	0.086	0.071	0.064
6	1½" Corkboard	0.149	0.078	0.066	0.064	0.055	0.052
7	2" Corkboard	0.119	0.062	0.054	0.053	0.047	0.044

PLASTERED MASONRY PARTITIONS

	The values of U in this Table are based on the following Internal Conductivities or Conductance which are expressed in B.t.u per Hr. per Sq. Ft. per 1°F Hollow Clay Tile (4") 0.93 per 4" Brick 5.00 per 1" Hollow Gypsum Tile 0.46 per 4"	Plain Walls (No Plaster)	Walls Plastered one side	Walls Plastered both sides
				
No.	Wall Construction	A	B	C
1	4" Hollow Clay Tile	0.390	0.360	0.333
2	4" Brick	0.437	0.400	0.367
3	4" Hollow Gypsum Tile	0.273	0.258	0.244

---

[a] The thickness of the gypsum fill is approximately 3⅝ in., the approximate 4 in. dimension of 2 in. by 4 in. studding.

[b] Metal lath and plaster assumed ¾ in. thick.

[c] Plaster assumed ½ in. thick.

[d] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

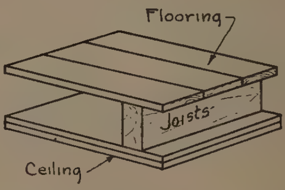
TABLE 29. COEFFICIENTS OF TRANSMISSION (*U*) OF FRAME CONSTRUCTION FLOORS AND CEILINGS

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON STILL-AIR (NO WIND) CONDITIONS ON BOTH SIDES.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Wood (Yellow Pine or Fir)	1.00 per 1"
Wood (Maple)	1.20 per 1"
Plaster (Gypsum)	2.32 per 1"
Plaster board	3.73 per 3/8"
Wood Lath & Plaster	2.00 as applied
Cork board	0.30 per 1"
Rigid Insulation (Board form)	0.33 per 1"
Cellular Gypsum (18*)	0.59 per 1"
Flaked Gypsum, Dry (18*)	0.34 per 1"
Flexible Insulation	0.27 per 1"

Typical Construction



Number	Type of Ceiling	Insulation between Joists	Type of Flooring			
			No Flooring	1" Yellow Pine[b] Flooring on Joists	1" Yellow Pine[b] Flooring on 1/2" Rigid Insulation (Board form) on Joists	13/16" Maple or Oak Flooring on 1" Yellow Pine Sub-flooring on Joists
			A	B	C	D
1	No Ceiling	None		0.440	0.264	0.339
2	Metal Lath & Plaster (3/4")	None	0.551	0.298	0.200	0.239
3	Wood Lath & Plaster (1/2")	None	0.502	0.272	0.192	0.230
4	3/8" Plaster board & Plaster (1/2")	None	0.506	0.273	0.193	0.230
5	1/2" Rigid Insulation (Board form) & Plaster (1/2")	None	0.310	0.204	0.156	0.179
6	Wood Lath & Plaster (1/2")	1/2" Flexible Insulation[a]	0.210	0.155	0.126	0.140
7	Wood Lath & Plaster (1/2")	1/2" Rigid Insulation (Board form)[a]	0.226	0.163	0.131	0.148
8	Wood Lath & Plaster (1/2")	Cellular Gypsum Fill (2")[d-c]	0.186	0.141	0.117	0.129
9	Wood Lath & Plaster (1/2")	Flaked Gypsum Fill (2")[c]	0.127	0.105	0.090	0.098
10	1 1/2" Cork board & Plaster (1/2")	None	0.149	0.119	0.101	0.110
11	2" Cork board & Plaster (1/2")	None	0.119	0.100	0.087	0.093

[a] The value of *U* is the same if insulation is applied to underside of joists and lath and plaster ceiling separated by furring strips.

[b] Based on actual thickness of approximately 25/32 in. for 1 in. yellow pine flooring.

[c] Thickness of fill assumed 2 in.

[d] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

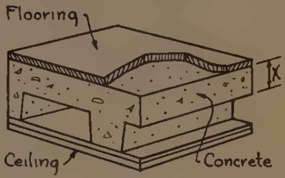
TABLE 30. COEFFICIENTS OF TRANSMISSION (U) OF CONCRETE CONSTRUCTION FLOORS AND CEILINGS

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON STILL-AIR (NO WIND) CONDITIONS ON BOTH SIDES.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Tile or Terrazzo	10.00	per 1"
Concrete (Stone 1:2:4 mix)	8.30	per 1"
Cement Mortar	8.00	per 1"
Wood (Yellow Pine or Fir)	1.00	per 1"
Wood (Maple)	1.20	per 1"
Plaster board	3.73	per $\frac{3}{8}$"
Plaster (Gypsum)	2.32	per 1"
Cork board	0.30	per 1"
Rigid Insulation (Board form)	0.33	per 1"

Typical Construction



Number	Type of Ceiling	Thickness—X	Type of Flooring			
			No Flooring[a] (Concrete bare)	1" Yellow Pine Flooring on Wood Sleepers embedded in Concrete[b]	$\frac{13}{16}$" Maple or Oak Flooring on 1" Yellow Pine Sub-Flooring on Wood Sleepers embedded in Concrete	1" Terrazzo or Tile Flooring on Concrete
			A	B	C	D
1	No Ceiling	4"	0.508	0.364	0.292	0.483
2		6"	0.452	0.334	0.273	0.433
3		8"	0.408	0.310	0.256	0.392
4		10"	0.372	0.288	0.241	0.358
5	$\frac{1}{2}$" Plaster applied directly to under-side of Concrete	4"	0.457	0.337	0.275	0.437
6		6"	0.411	0.311	0.258	0.395
7		8"	0.374	0.290	0.243	0.361
8		10"	0.344	0.271	0.230	0.332
9	Suspended or Furred Metal Lath & Plaster Ceiling	4"	0.312	0.251	0.215	0.303
10		6"	0.299	0.237	0.204	0.282
11		8"	0.272	0.224	0.195	0.264
12		10"	0.255	0.212	0.186	0.249
13	Suspended or Furred Ceiling of $\frac{3}{8}$" Plaster board & Plaster	4"	0.297	0.241	0.208	0.289
14		6"	0.277	0.228	0.198	0.270
15		8"	0.260	0.216	0.189	0.254
16		10"	0.245	0.206	0.181	0.239
17	Suspended or Furred Ceiling of $\frac{1}{2}$" Rigid Insulation (Board form) & Plaster	4"	0.217	0.185	0.165	0.212
18		6"	0.206	0.178	0.159	0.202
19		8"	0.197	0.170	0.153	0.193
20		10"	0.187	0.163	0.147	0.184
21	$\frac{1}{2}$" Plaster on $1\frac{1}{2}$" Cork board set in $\frac{1}{2}$" Cement Mortar on Concrete	4"	0.138	0.124	0.115	0.136
22		6"	0.133	0.121	0.112	0.132
23		8"	0.129	0.117	0.109	0.128
24		10"	0.125	0.114	0.106	0.124
25	$\frac{1}{2}$" Plaster on 2" Cork board set in $\frac{1}{2}$" Cement Mortar on Concrete	4"	0.112	0.103	0.097	0.111
26		6"	0.109	0.101	0.094	0.108
27		8"	0.106	0.098	0.092	0.105
28		10"	0.104	0.096	0.090	0.103

[a] The figures in column "A" are sufficiently accurate for concrete floors covered with carpet or linoleum.

[b] The figures in column "B" are sufficiently accurate for $^{13}\!/_{16}$ in. maple or oak flooring applied directly over the concrete on wood sleepers.

TABLE 31. COEFFICIENTS OF TRANSMISSION (*U*) OF CONCRETE CONSTRUCTION FLOORS ON GROUND[a]

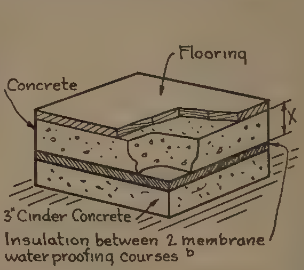
Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE GROUND AND THE AIR OVER THE FLOOR AND ARE BASED ON STILL-AIR (NO WIND) CONDITIONS.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Tile or Terrazzo	10.00 per 1"
Concrete (Stone 1:2:4 mix)	8.30 per 1"
Cinder Concrete	5.20 per 1"
Wood (Yellow Pine)	1.00 per 1"
Wood (Maple)	1.20 per 1"
Rigid Insulation (Board form)	0.33 per 1"
Cork board	0.30 per 1"

Y = Thickness of Insulation in Inches where specified

Typical Construction



Number	Type of Insulation (Between Cinder & Stone Concrete)	Thickness Y	Thickness X	Type of Flooring			
				No Flooring (Concrete bare)	1" Yellow Pine Flooring on Wood Sleepers embedded in Concrete[c]	13/16" Maple or Oak Flooring on 1" Yellow Pine Sub-Flooring on Wood Sleepers embedded in Concrete	1" Terrazzo or Tile Flooring on Concrete
				A	B	C	D
1	No Insulation	0"	4"	0.556	0.388	0.308	0.526
2		0"	5"	0.521	0.370	0.297	0.495
3		0"	6"	0.490	0.355	0.286	0.467
4		0"	8"	0.439	0.327	0.268	0.420
5	Rigid Insulation (Board form)	1"	4"	0.207	0.178	0.159	0.203
6		1"	5"	0.202	0.174	0.156	0.198
7		1"	6"	0.197	0.171	0.153	0.193
8		1"	8"	0.188	0.164	0.148	0.185
9	Cork board	2"	4"	0.118	0.108	0.101	0.117
10		2"	5"	0.116	0.107	0.100	0.115
11		2"	6"	0.115	0.105	0.098	0.113
12		2"	8"	0.112	0.103	0.096	0.110

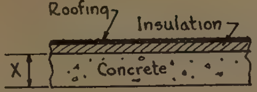
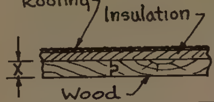
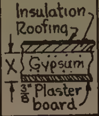
[a] Assume ground temperature to be 50 deg. fahr.

[b] Membrane waterproofing neglected in calculations.

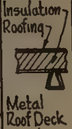
[c] The figures in column "B" may be used with sufficient accuracy for maple or oak flooring on wood sleepers embedded in concrete.

(UNDERSIDE OF ROOF EXPOSED)

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

<table>
<tr><td colspan="3" rowspan="3">The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq.Ft. per 1°F
Roofing 1.325 per 1"
Concrete 8.30 per 1"
Gypsum (Fiber Concrete) 1.66 per 1"
Wood (Yellow Pine or Fir) 1.00 per 1"
Rigid Insulation (Board form) 0.33 per 1"
Flexible Insulation 0.27 per 1"
Cork board 0.30 per 1"
Plaster board 3.73 per $\frac{3}{8}$"
Cellular Gypsum (24#) 0.77 per 1"
Lt. Wt. Heat treated Clay Aggregate Cement 1.62 per 1"</td><td colspan="6">Concrete Roofs
 </td><td colspan="5">Wood Roofs
 </td><td colspan="2">Gypsum Fiber Concrete (87½% Gypsum-12½% Wood Fiber)


Insulation
Roofing
X
Gypsum
$\frac{3}{8}$" Plaster board

</td><td rowspan="3">Flat Metal Roofs
 </td><td rowspan="3">Corrugated Iron Roofs
 </td></tr>
<tr><td colspan="6">Thickness – X</td><td colspan="5">Thickness – X[b]</td><td colspan="2">Thickness-X</td></tr>
<tr><td>1⅝"[a]</td><td>2"</td><td>3"</td><td>4"</td><td>5"</td><td>6"</td><td>1"</td><td>1½"</td><td>2"</td><td>3"</td><td>4"</td><td>2½"</td><td>3½"</td></tr>
<tr><td>Number</td><td>Thickness of Insulation</td><td>Kind of Insulation</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td><td>H</td><td>I</td><td>J</td><td>K</td><td>L</td><td>M</td><td>N</td><td>O</td></tr>
<tr><td>1</td><td>0"</td><td>No Insulation</td><td>0.680</td><td>0.658</td><td>0.610</td><td>0.568</td><td>0.532</td><td>0.500</td><td>0.485</td><td>0.386</td><td>0.345</td><td>0.256</td><td>0.204</td><td>0.354</td><td>0.292</td><td>0.781</td><td>1.50[c]</td></tr>
<tr><td>2</td><td>½"</td><td>Rigid Insulation (Board form)</td><td>0.334</td><td>0.330</td><td>0.317</td><td>0.306</td><td>0.295</td><td>0.285</td><td>0.280</td><td>0.243</td><td>0.226</td><td>0.184</td><td>0.156</td><td>0.230</td><td>0.202</td><td>0.358</td><td></td></tr>
<tr><td>3</td><td>1"</td><td></td><td>0.222</td><td>0.220</td><td>0.214</td><td>0.209</td><td>0.203</td><td>0.199</td><td>0.196</td><td>0.178</td><td>0.168</td><td>0.144</td><td>0.126</td><td>0.171</td><td>0.155</td><td>0.232</td><td></td></tr>
<tr><td>4</td><td>1½"</td><td></td><td>0.166</td><td>0.165</td><td>0.162</td><td>0.159</td><td>0.156</td><td>0.153</td><td>0.151</td><td>0.140</td><td>0.134</td><td>0.118</td><td>0.106</td><td>0.136</td><td>0.126</td><td>0.172</td><td></td></tr>
<tr><td>5</td><td>2"</td><td></td><td>0.133</td><td>0.132</td><td>0.130</td><td>0.128</td><td>0.126</td><td>0.124</td><td>0.123</td><td>0.116</td><td>0.112</td><td>0.100</td><td>0.091</td><td>0.112</td><td>0.106</td><td>0.136</td><td></td></tr>
<tr><td>6</td><td>1"</td><td>Cork board</td><td>0.208</td><td>0.206</td><td>0.201</td><td>0.196</td><td>0.192</td><td>0.188</td><td>0.185</td><td>0.169</td><td>0.160</td><td>0.138</td><td>0.121</td><td>0.163</td><td>0.148</td><td>0.217</td><td></td></tr>
<tr><td>7</td><td>1½"</td><td></td><td>0.154</td><td>0.153</td><td>0.151</td><td>0.148</td><td>0.145</td><td>0.143</td><td>0.142</td><td>0.132</td><td>0.126</td><td>0.124</td><td>0.101</td><td>0.128</td><td>0.119</td><td>0.160</td><td></td></tr>
<tr><td>8</td><td>2"</td><td></td><td>0.123</td><td>0.122</td><td>0.120</td><td>0.119</td><td>0.117</td><td>0.115</td><td>0.114</td><td>0.108</td><td>0.104</td><td>0.095</td><td>0.086</td><td>0.106</td><td>0.099</td><td>0.126</td><td></td></tr>
<tr><td>9</td><td>½"</td><td>Flexible Insulation (Not compressed)</td><td>0.301</td><td>0.297</td><td>0.286</td><td>0.277</td><td>0.268</td><td>0.260</td><td>0.256</td><td>0.225</td><td>0.210</td><td>0.174</td><td>0.148</td><td>0.214</td><td>0.190</td><td>0.319</td><td></td></tr>
<tr><td>10</td><td>1"</td><td></td><td>0.193</td><td>0.191</td><td>0.187</td><td>0.183</td><td>0.179</td><td>0.175</td><td>0.174</td><td>0.159</td><td>0.151</td><td>0.131</td><td>0.116</td><td>0.153</td><td>0.140</td><td>0.201</td><td></td></tr>
<tr><td>11</td><td>2"</td><td>Cellular Gypsum</td><td>0.246</td><td>0.243</td><td>0.236</td><td>0.229</td><td>0.223</td><td>0.217</td><td>0.214</td><td>0.193</td><td>0.182</td><td>0.154</td><td>0.133</td><td></td><td></td><td></td><td></td></tr>
</table>

[a] Pre cast cement tile. For heat-treated clay aggregate cement tile covered with roofing, $U = 0.438$ (1⅝ in. slab) and $U = 0.528$ (1 in. slab), based on a conductivity of 1.62 per 1 in.

[b] Nominal thicknesses specified—actual thicknesses used in computations.

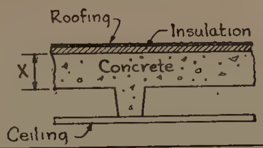
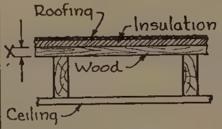
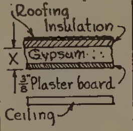
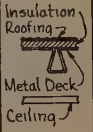
[c] No built-up roofing. The value for corrugated iron is obtained by assuming that the surface area is increased 50 per cent.

TABLE 33. COEFFICIENTS OF TRANSMISSION (U) OF FLAT ROOFS COVERED WITH BUILT-UP ROOFING WITH METAL LATH AND PLASTER CEILINGS[c]

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq.Ft. per 1°F

Roofing	1.325 per 1"
Concrete	8.30 per 1"
Gypsum (Fiber Concrete)	1.66 per 1"
Wood (Yellow Pine or Fir)	1.00 per 1"
Rigid Insulation (Board form)	0.33 per 1"
Flexible Insulation	0.27 per 1"
Corkboard	0.30 per 1"
Plaster board	3.73 per $\frac{3}{8}$"
Cellular Gypsum (24*)	0.77 per 1"
Plaster (Gypsum)	2.32 per 1"

Number	Thickness of Insulation	Kind of Insulation	Concrete Roofs						Wood Roofs					Gypsum Fiber Concrete ($87\frac{1}{2}$% Gypsum-$12\frac{1}{2}$% Wood Fiber)		Flat Metal Roofs
														 Roofing Insulation X Gypsum $\frac{3}{8}$" Plaster board Ceiling		
			Thickness –X						Thickness –X[b]					Thickness-X		
			$1\frac{5}{8}$"[a]	2"	3"	4"	5"	6"	1"	$1\frac{1}{2}$"	2"	3"	4"	$2\frac{1}{2}$"	$3\frac{1}{2}$"	
			A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	0"	No Insulation	0.370	0.363	0.348	0.334	0.321	0.309	0.304	0.262	0.242	0.195	0.163	0.247	0.215	0.398
2	$\frac{1}{2}$"	Rigid Insulation (Board form)	0.237	0.235	0.228	0.222	0.216	0.211	0.208	0.187	0.177	0.150	0.131	0.179	0.162	0.248
3	1"		0.174	0.173	0.169	0.166	0.163	0.160	0.158	0.146	0.140	0.123	0.109	0.141	0.130	0.180
4	$1\frac{1}{2}$"		0.138	0.137	0.135	0.133	0.131	0.129	0.128	0.120	0.115	0.104	0.094	0.116	0.108	0.142
5	2"		0.114	0.113	0.112	0.110	0.109	0.108	0.107	0.101	0.098	0.089	0.082	0.099	0.093	0.117
6	1"	Corkboard	0.166	0.164	0.161	0.158	0.155	0.153	0.151	0.140	0.134	0.118	0.106	0.135	0.125	0.113
7	$1\frac{1}{2}$"		0.130	0.129	0.127	0.125	0.123	0.121	0.121	0.113	0.110	0.099	0.090	0.110	0.104	0.133
8	2"		0.107	0.106	0.105	0.104	0.103	0.101	0.101	0.096	0.092	0.085	0.078	0.093	0.088	0.109
9	$\frac{1}{2}$"	Flexible Insulation (Not compressed)	0.219	0.217	0.212	0.207	0.202	0.197	0.194	0.176	0.167	0.143	0.126	0.169	0.154	0.229
10	1"		0.156	0.155	0.152	0.150	0.147	0.144	0.143	0.133	0.128	0.113	0.102	0.129	0.120	0.161
11	2"	Cellular Gypsum	0.188	0.187	0.183	0.179	0.175	0.172	0.170	0.156	0.148	0.129	0.114			

---

[a] Pre cast cement.

[b] Nominal thickness specified—actual thicknesses used in computations.

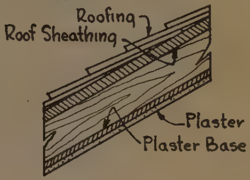
TABLE 34. COEFFICIENTS OF TRANSMISSION (U) OF PITCHED ROOFS OVER HEATED ATTICS

Note.—THESE COEFFICIENTS ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE FOOT PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR ON THE TWO SIDES AND ARE BASED ON AN OUTSIDE WIND EXPOSURE OF 15 MILES PER HOUR.

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Asphalt or Composition Roofing	6.50	as applied
Asbestos Shingles	6.00	as applied
Slate Shingles	10.37	per 1"
Wood (Yellow Pine or Fir)	1.00	per 1"
Wood Lath & Plaster	2.00	as applied
Plaster board	3.73	per $\frac{3}{8}$"
Plaster (Gypsum)	2.32	per 1"
Rigid Insulation (Board form)	0.33	per 1"
Flexible Insulation	0.27	per 1"
Cork board	0.30	per 1"
Cellular Gypsum (18#)	0.59	per 1"
Flaked Gypsum (24') Dry	0.48	per 1"

Typical Construction



Number	Type of Roofing and Roof Sheathing	Insulation between Roof Rafters	Type of Ceiling							
			No Ceiling	Metal Lath and $\frac{3}{4}$" Plaster	Plaster board $\frac{3}{8}$" and $\frac{1}{2}$" Plaster	Wood Lath and $\frac{1}{2}$" Plaster	$\frac{1}{2}$" Rigid Insulation & $\frac{1}{2}$" Plaster	1" Rigid Insulation & $\frac{1}{2}$" Plaster	$1\frac{1}{2}$" Cork board and $\frac{1}{2}$" Plaster	2" Cork-board and $\frac{1}{2}$" Plaster
			A	B	C	D	E	F	G	H
1	Wood Shingles on Wood Strips[a]	None	0.483	0.303	0.289	0.288	0.212	0.161	0.122	0.102
2		$\frac{1}{2}$" Flexible[b]		0.165	0.161	0.160	0.134	0.111	0.091	0.079
3		1" Flexible[b]		0.126	0.124	0.124	0.107	0.092	0.078	0.069
4		$3\frac{5}{8}$" Cellular Gypsum[c]		0.112	0.110	0.110	0.097	0.085	0.072	0.065
5		$3\frac{5}{8}$" Flaked Gypsum[c]		0.097	0.096	0.096	0.085	0.076	0.066	0.059
6	Asphalt Shingles or Composition Roofing on Wood Sheathing	None	0.518	0.316	0.301	0.300	0.219	0.164	0.124	0.103
7		$\frac{1}{2}$" Flexible[b]		0.169	0.165	0.164	0.136	0.113	0.092	0.080
8		1" Flexible[b]		0.129	0.126	0.126	0.109	0.094	0.079	0.070
9		$3\frac{5}{8}$" Cellular Gypsum[c]		0.120	0.117	0.117	0.102	0.088	0.076	0.067
10		$3\frac{5}{8}$" Flaked Gypsum[c]		0.102	0.101	0.101	0.089	0.079	0.068	0.061
11	Rigid Asbestos Shingles on Wood Sheathing	None	0.515	0.315	0.300	0.298	0.218	0.164	0.124	0.103
12		$\frac{1}{2}$" Flexible[b]		0.169	0.164	0.164	0.136	0.113	0.092	0.080
13		1" Flexible[b]		0.129	0.126	0.126	0.109	0.093	0.079	0.070
14		$3\frac{5}{8}$" Cellular Gypsum[c]		0.119	0.117	0.117	0.102	0.088	0.075	0.067
15		$3\frac{5}{8}$" Flaked Gypsum[c]		0.102	0.101	0.100	0.089	0.079	0.068	0.061
16	Slate or Tile and Roofing Felt on Wood Sheathing	None	0.548	0.327	0.311	0.309	0.224	0.167	0.126	0.104
17		$\frac{1}{2}$" Flexible[b]		0.172	0.167	0.167	0.138	0.114	0.093	0.081
16		1" Flexible[b]		0.131	0.128	0.127	0.110	0.095	0.080	0.070
17		$3\frac{5}{8}$" Cellular Gypsum[c]		0.121	0.118	0.118	0.103	0.089	0.076	0.067
18		$3\frac{5}{8}$" Flaked Gypsum[c]		0.103	0.101	0.101	0.090	0.079	0.069	0.062

[a] Based on 1 in. by 4 in. strips spaced 2 in.

[b] Can also be applied to underside of roof rafters with furring strips between.

[c] Assumed 3⅝ in. thick, based on 2 in. by 4 in. rafters.

The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

TABLE 35. COEFFICIENTS OF TRANSMISSIC

Note.—THE FIGURES ON THESE PAGES ARE THE COMBINED COEFFICIENTS OF TRANSMISSION OF FOOT OF ROOF AREA PER 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR UNDERNE COEFFICIENTS ARE BASED ON ONE-THIRD PITCHED ROOFS, BUT ARE SUFFICIENTLY ACCURATE FO

The values of U in this Table are based on the following Internal Conductivities or Conductances which are expressed in B.t.u. per Hr. per Sq. Ft. per 1°F

Asphalt or Composition Roofing	6.50 as applied
Asbestos Shingles	6.00 as applied
Slate Shingles	10.37 per 1"
Wood (Yellow Pine or Fir)	1.00 per 1"
Wood Lath & Plaster	2.00 as applied
Plaster board	3.73 per 3/8"
Plaster (Gypsum)	2.32 per 1"
Rigid Insulation (Board form)	0.33 per 1"
Flexible Insulation	0.27 per 1"
Cork board	0.30 per 1"
Cellular Gypsum (18#)	0.59 per 1"
Flaked Gypsum, Dry (18#)	0.34 per 1"

Number	Roofing and Roof Sheathing	Insulation between Ceiling Joists	No Attic Flooring			
			Wood Lath and Plaster Ceiling	3/8" Plaster board & Plaster Ceiling	1/2" Rigid Insulation & Plaster Ceiling	1" Rigid Insulation & Plaster Ceiling
			A	B	C	D
1	Wood Shingles on Wood Strips[a]	None	0.263	0.264	0.190	0.141
2		1/2" Flexible [b]	0.141	0.141	0.116	0.096
3		2" Cellular Gypsum [d]	0.126	0.126	0.107	0.090
4		2" Flaked Gypsum	0.092	0.092	0.081	0.071
5	Asphalt Shingles or Composition Roofing on Wood Sheathing	None	0.272	0.273	0.194	0.143
6		1/2" Flexible [b]	0.143	0.143	0.118	0.097
7		2" Cellular Gypsum [d]	0.128	0.128	0.108	0.090
8		2" Flaked Gypsum	0.093	0.093	0.081	0.071
9	Rigid Asbestos Shingles on Wood Sheathing	None	0.271	0.272	0.194	0.143
10		1/2" Flexible [b]	0.143	0.143	0.118	0.097
11		2" Cellular Gypsum [d]	0.128	0.128	0.108	0.090
12		2" Flaked Gypsum	0.093	0.093	0.081	0.071
13	Slate or Tile and Roofing Felt on Wood Sheathing	None	0.280	0.281	0.198	0.145
14		1/2" Flexible [b]	0.145	0.145	0.120	0.098
15		2" Cellular Gypsum [d]	0.130	0.130	0.109	0.090
16		2" Flaked Gypsum	0.093	0.093	0.082	0.072

[a] Based on 1 in. by 4 in. spaced 2 in.

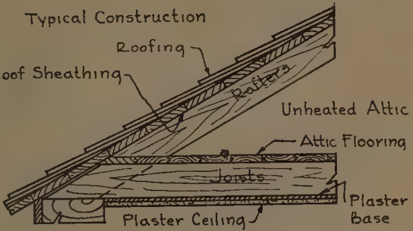
[b] Can also be applied to underside of ceiling joists with furring strips between insulation an

[c] Based on actual thickness of 1 in. lumber of approximately 25/32 in.

[d] The coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may

ED ROOFS WITH UNHEATED ATTICS

EATED ATTICS, AND TOP-FLOOR CEILINGS, AND ARE EXPRESSED IN B.T.U. PER HOUR PER SQUARE
D THE OUTSIDE AIR. AN AVERAGE WIND EXPOSURE OF 15 MILES HAS BEEN ASSUMED. THESE
ROM ONE-QUARTER PITCH TO ONE-HALF PITCH.



		1"x6" Yellow Pine Attic Flooring					
1½" Cork-board & Plaster Ceiling	2" Cork-board & Plaster Ceiling	Wood Lath and Plaster Ceiling	⅜" Plaster board & Plaster Ceiling	½" Rigid Insulation & Plaster Ceiling	1" Rigid Insulation & Plaster Ceiling	1½" Cork-board & Plaster Ceiling	2" Cork-board & Plaster Ceiling
E	F	G	H	I	J	K	L
0.106	0.088	0.172	0.172	0.136	0.109	0.087	0.074
0.078	0.068	0.109	0.109	0.094	0.080	0.068	0.060
0.074	0.064	0.101	0.101	0.088	0.076	0.064	0.057
0.061	0.054	0.078	0.078	0.070	0.062	0.053	0.049
0.107	0.088	0.175	0.175	0.138	0.110	0.087	0.075
0.079	0.068	0.110	0.110	0.095	0.081	0.068	0.060
0.075	0.064	0.102	0.102	0.088	0.076	0.064	0.057
0.061	0.054	0.078	0.078	0.070	0.062	0.054	0.049
0.107	0.088	0.175	0.175	0.138	0.110	0.087	0.075
0.079	0.068	0.110	0.110	0.095	0.081	0.068	0.060
0.075	0.064	0.102	0.102	0.088	0.076	0.064	0.057
0.061	0.054	0.078	0.078	0.070	0.062	0.054	0.049
0.108	0.089	0.179	0.179	0.140	0.111	0.088	0.076
0.080	0.068	0.111	0.111	0.096	0.081	0.068	0.060
0.076	0.065	0.103	0.103	0.089	0.076	0.065	0.058
0.061	0.054	0.078	0.078	0.070	0.062	0.054	0.049

d on 1 in. by 4 in. spaced 2 in.
also be applied to underside of ceiling joists with furring strips between insulation and ceiling.
d on actual thickness of 1 in. lumber of approximately 15/16 in.
coefficient used for cellular gypsum, 0.59 is for 18 lb. weight—weights as low as 12 lb. may be used.

TABLE 36. COEFFICIENTS OF TRANSMISSION (U) OF DOORS, WINDOWS AND SKYLIGHTS

Note.—THESE COEFFICIENTS ARE BASED ON A WIND EXPOSURE OF 15 MILES PER HOUR, AND ARE EXPRESSED IN B.T.U. PER HOUR, PER SQUARE FOOT, PER DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN THE AIR INSIDE AND OUTSIDE OF THE DOOR, WINDOW OR SKYLIGHT.

A. Windows and Skylights

	U
Single	1.13[a-c]
Double	0.45[a]
Triple	0.281[a]

B. Solid Wood Doors[b-c]

NOMINAL THICKNESS INCHES	ACTUAL THICKNESS INCHES	U
1	25/32	0.563
1¼	1 1/16	0.485
1½	1 5/16	0.432
1¾	1⅜	0.421
2	1⅝	0.382
2½	2⅛	0.321
3	2⅝	0.277

[a] See page 212, Volume I, *Mechanical Equipment of Buildings*, by Harding and Willard, second edition, 1929.

[b] Computed using $C = 1.0$ for wood; $f_i = 1.34$ and $f_o = 4.02$.

[c] It is sufficiently accurate to use the same coefficient of transmission for doors containing thin wood panels, as that of single panes of glass, namely, 1.13 B.t.u. per hour per square foot per 1 deg. fahr. difference between inside and outside air temperature.

HEAT LOSSES BY INFILTRATION

Heat Required to Warm Air Leaking into Building

In addition to the heat transmission of the walls, glass and roof, consideration must always be given to the inleakage of cold outside air which must be heated to room temperature. This inleakage or infiltration is exclusive and independent of air that may be supplied for ventilation through ducts or flues of any sort. Calculation of the heat required for this purpose is a very simple matter if the volume of air leaking into the building per hour is known.

$$H_i = 0.24\, Q\, d\, (t - t_o) \qquad (16)$$

where

H_i = B.t.u. per hour required for heating air leaking into building from outside temperature t_o to breathing-line temperature t.

Q = cubic feet of air entering per hour at breathing-line temperature, t.

d = density (pounds per cubic feet) of air at breathing-line temperature, t

t = breathing-line temperature.

t_o = outside air temperature for which heating system is designed.

0.24 = specific heat of air.

Infiltration through Materials

It is possible for infiltration to take place through certain types of porous materials, but such infiltration is reduced to a minimum by good workmanship and by the use of building paper and plaster.

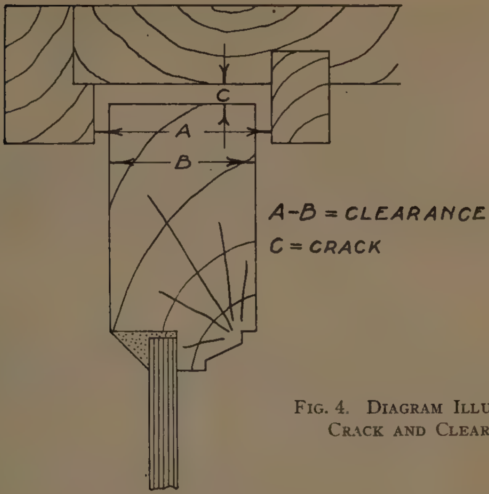


Fig. 4. Diagram Illustrating Crack and Clearance

Table 37 gives the leakage through brick and wood-frame walls, with and without plaster. In addition to the information in this table, the authors make the following statement: "In the case of walls with furring, lath, and plaster painted, walls plastered directly on the brick with or without paint or frame walls with plaster painted, the leakage is so small as to require about 0.10 of a square foot of radiation per 100 sq. ft. of wall, or in fact, it could be said that the heat loss due to infiltration of such walls is negligible."

Infiltration through Cracks

Definitions of Crack and Clearance: Fig. 4 illustrates what is meant by crack and clearance. The crack around the sash perimeter is equal to one half the difference between the width of the frame and the width of the sash, that is, the crack is the same on each side of the sash. The clearance is the difference between the width of the stile and the thickness of the sash. These terms are chosen arbitrarily to distinguish the two principal air passages which are found in double-hung windows.

The linear feet of crack for a double-hung sash is equal to the sash perimeter plus the meeting rail. For a standard type steel sash constructed of solid rolled sections the linear feet of crack consists of the perimeter of the ventilating section plus the linear feet of sash section in contact with steel work as, for example, vertical and horizontal mullion steel. The perimeter of sash properly grouted with cement mortar into brickwork or concrete is not to be counted as crack.

In no case should the amount of crack used for computation be less than half of the total crack in the outside walls of the room. Thus, in a room with one exposed wall, take all the crack; with two exposed walls, take the wall having the most crack; and with three or four exposed walls, take the wall having the most crack, but in no case take less than half the total crack.

Methods for Determining Infiltration

The determination of Q, the amount of air leaking in per hour, may be arrived at in either of two ways: (1) by assuming a certain number of air changes per hour for each room, the number of changes assumed (Table 38) being dependent upon the type, use, and location of room, or (2) by computing the infiltration taking place through the cracks around windows and doors in that side of the room which has the greatest number of feet of such crack.

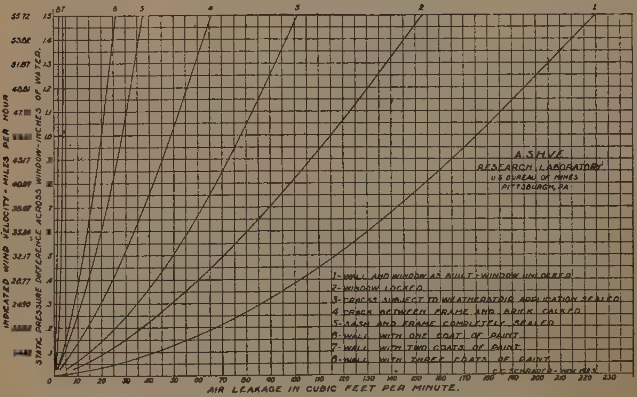


FIG. 5. RESULTS OF TESTS OF LEAKAGE THROUGH VARIOUS PARTS OF WINDOW AND FRAME

Neither of these methods for estimating the infiltration is entirely satisfactory in view of the limited amount of data available, but for the purposes of calculation the second (infiltration) method is to be preferred and then checked against the first (air changes per hour) method. In no case use less than one-half an air change where outside doors and windows exist.

Leakage through Various Parts of Window and Frame: The results of tests of leakage through various parts of a window and frame are shown in Fig. 5.

The principal facts brought out in these tests were that increasing the crack around the perimeter of a plain sash does not materially increase the leakage, and that weatherstripped sash, while permitting much less leakage, shows a small increase in leakage with increase in crack. These facts were established by making several hundred tests.

Double-Hung Wood Sash Windows: Table 39, pertaining to double-hung wood sash windows, shows the amount of leakage for various wind

TABLE 37. INFILTRATION THROUGH VARIOUS TYPES OF WALL CONSTRUCTION[a]

	WIND VELOCITY MILES PER HOUR	8½ IN. BRICK WALL[c]			8½ IN. BRICK WALL[c] PLASTERED[b]			13 IN. BRICK WALL[c]			13 IN. BRICK WALL[c] PLASTERED[b]			FRAME WALL WITHOUT LATH AND PLASTER[b]			FRAME WALL WITH LATH AND PLASTER[b]		
		Leakage Cu. Ft. per Sq. Ft. per Hour	B.t.u. per Hour per Sq. Ft. 0-70°F.	Equiv. Steam Radiation Sq. Ft. per 100 Sq. Ft. of Wall Area	Leakage Cu. Ft. per Sq. Ft. per Hour	B.t.u. per Hour per Sq. Ft. 0-70°F.	Equiv. Steam Radiation Sq. Ft. per 100 Sq. Ft. of Wall Area	Leakage Cu. Ft. per Sq. Ft. per Hour	B.t.u. per Hour per Sq. Ft. 0-70°F.	Equiv. Steam Radiation Sq. Ft per 100 Sq. Ft. of Wall Area	Leakage Cu. Ft. per Sq. Ft. per Hour	B.t.u. per Hour per Sq. Ft. 0-70°F.	Equiv. Steam Radiation Sq. Ft. per 100 Sq. Ft. of Wall Area	Leakage Cu. Ft. per Sq. Ft. per Hour	B.t.u. per Hour per Sq. Ft. 0-70°F.	Equiv. Steam Radiation Sq. Ft. per 100 Sq. Ft. of Wall Area	Leakage Cu. Ft. per Sq. Ft. per Hour	B.t.u. per Hour per Sq. Ft. 0-70°F.	Equiv. Steam Radiation Sq. Ft. per 100 Sq. Ft. of Wall Area
PART I Values actually determined by Laboratory tests.	5.0	2.18	2.75	1.15	0.021	0.026	0.011	1.80	2.27	0.945	0.006	0.008	0.003	5.50	6.93	2.88	0.102	0.138	0.057
	10.0	5.24	6.60	2.75	0.046	0.058	0.024	4.90	6.19	2.58	0.16	0.020	0.008	16.00	20.20	8.40	0.270	0.340	0.141
	15.0	9.81	12.30	5.13	0.083	0.105	0.044	9.35	11.90	4.90	0.031	0.039	0.016	28.70	36.20	15.10	0.521	0.656	0.272
	20.0	15.30	19.30	8.04	0.134	0.169	0.070	14.50	18.30	7.63	0.054	0.068	0.028	45.00	56.70	23.60	0.796	1.000	0.416
	25.0	23.20	29.20	12.20	0.201	0.253	0.105	20.30	25.60	10.70	0.084	0.105	0.044	60.00	75.60	31.40	1.070	1.350	0.562
	30.0	28.60	36.10	15.10	0.295	0.372	0.155	26.50	33.40	13.90	0.121	0.153	0.064	76.90	96.90	40.30	1.330	1.670	0.695
	40.0	43.50	54.80	22.80	0.543	0.685	0.285	39.80	50.20	20.90	....	....	....	108.00	136.00	56.60	1.860	2.340	0.975
PART II Values for practical use; average test values reduced by 20 per cent to allow for building up of pressure in room, etc.	5.0	1.75	2.21	0.92	0.017	0.021	0.009	1.44	1.82	0.77	0.005	0.006	0.003	4.40	5.55	2.31	0.082	0.103	0.043
	10.0	4.20	5.29	2.20	0.037	0.047	0.020	3.92	4.95	2.06	0.013	0.016	0.007	12.80	16.10	6.71	0.216	0.272	0.113
	15.0	7.85	9.90	4.12	0.066	0.083	0.035	7.48	9.45	3.93	0.025	0.032	0.013	23.00	29.00	12.10	0.417	0.525	0.219
	20.0	12.20	15.40	6.41	0.107	0.135	0.056	11.60	14.60	6.10	0.043	0.054	0.022	36.00	45.40	18.90	0.637	0.802	0.334
	25.0	18.60	23.40	9.75	0.161	0.203	0.085	16.30	20.60	8.55	0.067	0.085	0.035	48.00	60.50	25.20	0.856	1.080	0.450
	30.0	22.90	28.90	12.10	0.236	0.297	0.124	21.20	26.70	11.10	0.097	0.122	0.051	61.50	77.50	32.30	1.060	1.340	0.557
	40.0	34.80	43.80	18.30	0.435	0.548	0.228	31.80	40.10	16.70	....	....	....	86.40	109.00	45.30	1.490	1.880	0.783

[a] The values given in the above table were derived from experiments conducted at the Research Laboratory on only a few samples of both brick and frame walls, and while they may be assumed to represent average walls or average conditions there might be a wide difference in the value between well built walls of both constructions, and those not so built. Further tests are now being conducted to verify this.

[b] It will be noted that the loss through plastered walls can be neglected.

[c] Published in the JOURNAL, A. S. H. V. E., Vol. 33, No. 4, April, 1927.

TABLE 38. AIR CHANGES TAKING PLACE UNDER AVERAGE CONDITIONS EXCLUSIVE OF AIR PROVIDED FOR VENTILATION

KIND OF ROOM OR BUILDING	NUMBER OF AIR CHANGES TAKING PLACE PER HOUR
Rooms, 1 side exposed	1
Rooms, 2 sides exposed	1½
Rooms, 3 sides exposed	2
Rooms, 4 sides exposed	2
Rooms with no windows or outside doors	½ to ¾
Entrance Halls	2 to 3
Reception Halls	2
Living Rooms	1 to 2
Dining Rooms	1 to 2
Bath Rooms	2
Drug Stores	2 to 3
Clothing Stores	1
Churches, Factories, Lofts, etc.	½ to 3

velocities per foot of uncalked crack around the frame, which can be almost entirely stopped by proper calking, and is taken from a paper entitled *Air Leakage*, by Houghten and Schrader. (TRANSACTIONS, A. S. H. V. E., Vol. 30, 1924).

This table also indicates the amount of leakage per foot of crack around the sash including meeting rail for cracks of 1/16 in. and in clearances of 7/64 in., for both plain and average weatherstripped windows, unlocked. It will be noted that this table is divided into two parts, the first part containing values based upon the original test data, and the second part containing the same values reduced by 20 per cent.

According to the authors of the paper: "The values given in the tables are from the tests as made and are probably somewhat higher than those actually found in practice. They represent the leakage when the pressure drop through the window is a certain value which represents a definite wind velocity at right angles to the window. If the wind strikes the window at an oblique angle the component of the velocity at right angles to the window must be considered. Pressure difference between the outside and the inside surfaces of the window for an actual wind will be slightly less for a given velocity because of a building up of pressure within the room before the air leaks out the opposite side of the building. Attention is called to the fact that air leaks in on the windward side of the building and out on the leeward side and, since wind will blow from various directions at different times, heating for any room having only one exposure must be based on the maximum loss. The heating plant, however, need not be figured on the sum of all maximum leakages, but in general only half of the total. However, the table gives accurate comparative figures which are probably not much too high for actual practice. In order to apply these values, a further study of the overall results as found in practice should be made, and the figures modified, if necessary, to fit practical conditions."

Fig. 6 gives the results of tests of a plain double-hung window with various clearances, and is taken from a paper entitled *Air Leakage Around*

Window Openings, by C. C. Schrader. (TRANSACTIONS, A. S. H. V. E., Vol. 30, 1924, No. 704). Four sets of sash were fitted with cracks of 1/16, 1/8, 3/16 and 1/4 in. Each set was tested with clearances varying from 1/32 to 1/4 in. Each test was repeated a number of times because no tests gave exactly the same leakage, and it was necessary to obtain average results. The tests proved that the size of the crack around the perimeter of the sash had no appreciable effect on the leakage. Therefore, the results apply to any window of the type tested with a crack of from 1/16 to 1/4 in. (Most new sashes are fitted with the crack at least 1/16 in., and this crack becomes greater as the sash dries out and shrinks). Fig. 6 shows that the leakage increases rapidly with increase in clearance.

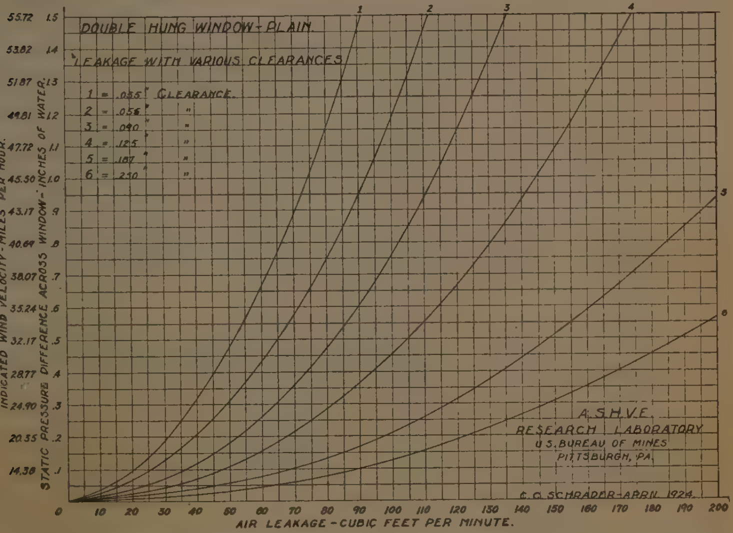


FIG. 6. LEAKAGE THROUGH PLAIN WOOD WINDOW WITH VARIOUS CLEARANCES

Note.—The above curves show the leakage for the total crack. To obtain the leakage in cubic feet per hour per foot of crack, multiply by 60 and divide by 18.25.

Double-Hung Metal Sash Windows: Table 40, pertaining to double-hung metal sash windows, is based on data obtained from tests conducted in the Southwestern Bell Telephone Co., St. Louis, Mo., and reported in a paper entitled *Saving Heat in Skyscrapers*, by Houghten and McConnell. (JOURNAL, A. S. H. V. E., Vol. 33, No. 11, Nov., 1927.)

This table contains data for non-weatherstripped windows, locked and unlocked, and weatherstripped windows, unlocked. As in the case of Table 39, the actual test results are reduced by 20 per cent to allow for the building up of pressure within the room before the air leaks out the opposite side of the building.

Rolled Section Steel Windows: Data concerning industrial pivoted, architectural projected, residential casement, and heavy casement section projected windows are given in Table 41.

The industrial pivoted window is generally employed in industrial buildings. The ventilators are pivoted, usually horizontally at the center or slightly above, the lower part of the ventilator swinging out and the upper part swinging in.

Architectural projected is a type of window usually manufactured of the same sections as the industrial pivoted window, except that the outside framing member is usually heavier, and there are refinements in the weathering and hardware, with the result that this window is usually used in the semi-monumental type of building such as schools. The ventilators swing in or out and are balanced on side arms.

The heavy section casement is a window manufactured of the so-called heavy casement sections. The leaves are hinged at the side and usually swing out.

Heavy casement section projected is a window manufactured of the same kind of sections as the heavy section casement window. The ventilators swing out or in, and are balanced on side arms that cause the ventilators to stay put at any degree of opening.

The residential casement window is of the same design, and is manufactured of the same shaped sections as those used in heavy section casement, but lighter in weight, and the swinging leaves cannot be built so large.

Pivoted Steel Windows: Table 42 presents some figures for infiltration through a steel window of the hollow-metal vertical-pivoted type tested in place in the Grand Central Palace Building, New York City.

The crack width was not given, but it was stated that the sash was not in good shape and fitted loosely in the frame.

Frame Calking and Storm Windows: Figs. 7 and 8 show the results of tests that were made at the University of Wisconsin to establish the value of storm sash for reducing infiltration, and reported in a paper entitled *Effect of Frame Calking and Storm Windows on Infiltration Around and Through Windows*, by Richtmann and Braatz. (Journal, A. S. H. V. E., Vol. 34, No. 9, September, 1928). While the tests were made on storm sash only, the results and conclusions would no doubt also apply to storm doors.

The curves on Fig. 7 show the infiltration through the sash perimeter of a window with 5/64 in. crack and 1/32 in. clearance before and after storm sash have been applied. Curve *A* is for the window without storm sash, *B* for the window with storm sash suspended by the hook and eye arrangement, *C* for the window with storm sash fastened with four turn-buttons, and *D* is the same as *C* except a felt strip was placed between the storm sash and the window frame. This last condition could be used to advantage where the windows are fastened by means of the turn-buttons.

The curves on Fig. 8 correspond to curves *A*, *B* and *C* of Fig. 7 except that the window is fitted with a 1/8 in. crack and 1/8 in. clearance.

A study of these curves leads to the conclusion that a storm sash is of little value in reducing infiltration when applied to a well-fitted window, but that a reduction of about 50 per cent might be expected when storm sash is securely applied to a poorly-fitted or loose window. Curves *B* and *C*, Fig. 8, show that much better results are obtained by means of turn-buttons on the outside than by securing the storm sash with toggle-links on the inside.

Calculations for Infiltration

In order to arrive at the heat required for warming up the air entering by infiltration, the following procedure is necessary:

1. Determine the average wind movement in miles per hour for the locality in question (Table 3).

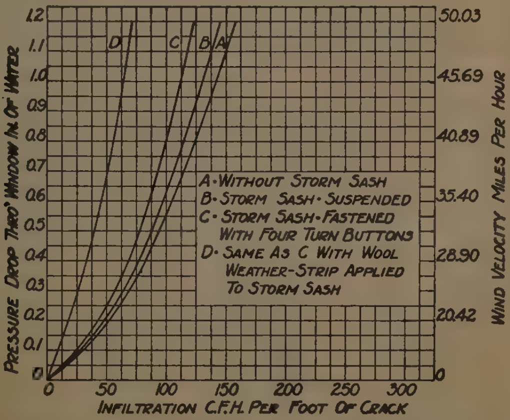


Fig. 7. Infiltration through Sash Perimeter of Window with and without Storm Sash—5/64 in. Crack and 1/32 in. Clearance

2. Determine the inleakage of outside air per lineal foot of the given window or door crack in cubic feet per minute at the given wind velocity, Tables 39 to 42, inclusive.

3. Express the heat equivalent in B.t.u. per hour per foot of crack to heat this air 1 deg. fahr.

Thus, for a plain wood window having 1/16 in. *crack* and 7/64 in. *clearance* (see Fig. 4), which means the air channel around the edge of the sash is approximately 1/16 in. wide, the heat equivalent of the air leaking in for a 0 to 70 deg. fahr. temperature difference is 157 B.t.u. per foot of crack per hour (Table 39, Part II). This value is found in the sixth column of the table. The computation for obtaining 157 is:

$$124 \times 0.075 \times 0.24 \times 70 = 157 \text{ B.t.u.}$$

where

124 = cubic feet of air per foot of crack per hour for a 15-mile wind for 7/64 in. clearance from the 5th column of Table 39.
0.075 = air density at 70 deg. fahr., pound per cubic foot.
0.24 = specific heat of air, and
70 = difference in temperature between inside and outside air.

The most convenient values for use in infiltration calculations are the coefficients of infiltration for the particular kind of crack with a wind velocity of 15 miles per hour under average conditions, with $\frac{1}{16}$ in. *crack* and $\frac{7}{64}$ in. *clearance* reduced by 20 per cent (Table 39, Part II).

For a wind velocity other than 15 miles per hour, use the proper velocity for that locality in place of 15. For temperature gradients other than 70 deg. multiply the value given in the tables by the new temperature gradient and divide by 70. For special cases involving unplastered walls or storm sash use values obtained from Table 37 or Figs. 7 and 8.

Infiltration Due to Temperature Difference

Even without wind movement, a difference of temperature between inside and outside of a building will cause the pressure state inside to be less than that outside near the ground, and greater near the roof; infiltration will occur at windows in the lower part of the building, and exfiltration at windows in the upper part. Thus in the case of a building 200 ft. high, arranged in stories with more or less free communication from one to another, and with a temperature difference of 70 deg., the pressure causing infiltration near the ground, and exfiltration near the roof, may easily exceed 0.20 in. of water, which is the equivalent of a twenty-mile wind.

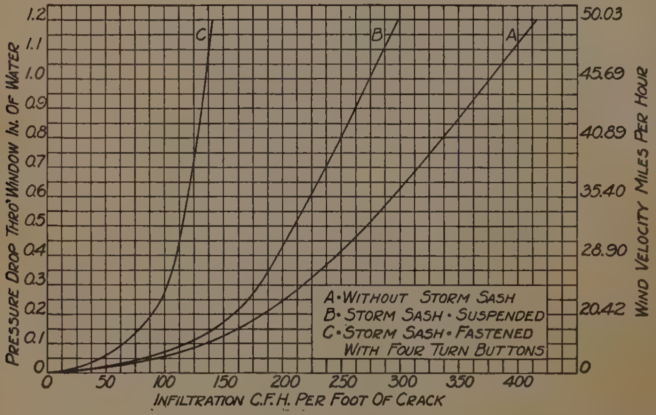


Fig. 8. Infiltration through Sash Perimeter of Window with and without Storm Sash—⅛ in. Crack and ⅛ in. Clearance

The factors influencing the pressures causing infiltration are so numerous that it does not seem wise at this time to attempt to include any quantitative values to express the effect of temperature difference, but it is something that should be kept in mind in the design and operation of heating systems in tall buildings.

TABLE 39. INFILTRATION THROUGH DOUBLE HUNG WOOD SASH WINDOWS[a-e]

	Wind Velocity Miles per Hour	Per Foot of Uncalked Crack Around Frame[c]			Per Foot of Crack around the Sash, including meeting rail for Cracks of 1/16 in. and 7/64 in. Clearance, Window Unlocked					
					Plain Non-Stripped Wood Window[b]			Average Weatherstripped Window[b]		
		Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0–70 Deg. Fahr.	Equivalent Steam Radiation Sq. Ft.[d]	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0–70 Deg. Fahr.	Equivalent Steam Radiation Sq. Ft.[d]	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0–70 Deg. Fahr.	Equivalent Steam Radiation Sq. Ft.[d]
PART I Values actually determined by Laboratory tests.	5.0	1.76	2.22	0.009	49.1	62.0	0.26	3.75	4.76	0.020
	7.5	7.95	10.1	0.042	78.6	99.1	0.42	8.52	10.8	0.045
	10.0	14.1	17.9	0.075	106.0	134.0	0.56	14.7	18.7	0.078
	15.0	28.3	35.9	0.15	155.0	196.0	0.82	28.6	36.4	0.15
	20.0	38.8	49.3	0.21	201.0	254.0	1.06	43.6	55.4	0.23
	30.0	67.1	85.3	0.36	291.0	367.0	1.54	74.5	93.9	0.39
	40.0	95.0	121.0	0.51	386.0	487.0	2.03	110.0	138.0	0.58
	50.0	111.0	141.0	0.59	488.0	615.0	2.56	146.0	185.0	0.78
PART II Values for practical use; average test values reduced by 20 per cent to allow for building up of pressure in room, etc.	5.0	1.41	1.77	0.007	39.3	49.5	0.21	3.00	3.80	0.016
	7.5	6.36	8.08	0.034	62.8	79.2	0.33	6.82	8.60	0.036
	10.0	11.3	14.3	0.060	84.9	107.0	0.45	11.7	14.9	0.062
	15.0	22.6	28.7	0.12	124.0	157.0	0.65	22.9	29.1	0.12
	20.0	31.1	39.4	0.16	161.0	203.0	0.85	34.9	44.3	0.19
	30.0	53.6	68.2	0.28	233.0	294.0	1.23	59.6	75.6	0.32
	40.0	76.0	96.5	0.40	309.0	390.0	1.63	87.8	111.0	0.46
	50.0	88.9	114.0	0.48	390.0	492.0	2.05	117.0	148.0	0.62

[a] This table is approximately correct for cracks up to 1/4 in.

[b] The values given for the plain non-stripped wood window and for the weatherstripped window include the "elsewhere" leakage through the frame, but not the leakage through the uncalked crack around the frame. If the frame is to be left uncalked the loss under that heading should be included in the heat loss calculations.

[c] Practically all leakage around frames can be stopped by proper calking.

[d] Based on heat emission of 240 B.t.u. per sq. ft.

[e] See *Air Leakage*, by Houghten and Schrader (TRANSACTIONS, A. S. H. V. E., Vol. 30, 1924, No. 686.)

Economic Value of Weatherstripping

Tables 39 and 40 show the heat losses in B.t.u. per hour per foot of crack for plain windows and weatherstripped windows to heat the incoming air from 0 to 70 deg. fahr. The tables also show the radiation in square feet that must be installed to take care of these heat losses. This radiation is based on a heat emission factor of 240 B.t.u. per square foot.

For example, consider a double-hung window at a wind velocity of 15 miles per hour. For a plain non-stripped window, Table 39 shows that 0.65 sq. ft. of radiation is required to take care of the infiltration loss per foot of crack. This table shows for the weatherstripped window, a corresponding radiation requirement of 0.12 sq. ft. per foot of crack, indicating that the application of good weatherstripping has brought about a reduction of 0.53 sq. ft. in the radiation required per foot of crack.

Assuming the heating system costs $2.00 per square foot of radiation installed, and weatherstripping to cost $0.30 per lineal foot installed, there would result for each $0.30 invested in weatherstripping, a reduction of $1.06 in the initial cost of the heating system. For any particular installation the costs applying to that locality and for that particular type of construction should be used in making such a cost analysis. No attempt is made here to figure the reduction in operating cost due to the application of weatherstripping, as this varies greatly depending on how the plant is operated.

WIND MOVEMENT

The effect of wind on the heating requirements of any building should be given consideration under two heads:

1. Wind movement increases the heat transmission of walls, glass, and roof, affecting poor walls to a much greater extent than good walls.

2. Wind movement materially increases the infiltration (inleakage) of cold air through the cracks around doors and windows, and even through the building materials themselves, if such materials are at all porous.

It is entirely possible that a building may require more heat on a windy day with a moderately low outside temperature than on a quiet day with a much lower outside temperature. It will, therefore, be evident that the wind movement in any locality must be given careful consideration in computing the probable heating requirements of a building, and for the purposes of calculation, not less than the average wind movement in any locality during December, January and February should always be provided for in computing (1) the heat transmission of a building, and (2) the heat required to take care of the infiltration of outside air.

The first condition is readily taken care of, as already explained, by using a surface coefficient f_o for the outside wall surface which is based on the proper wind velocity (Table 5). In case specific data are lacking for any locality, use an average wind velocity of approximately 15 miles per hour. In a similar manner, the heat allowance for infiltration through cracks (Tables 39 to 42), must be based on the average wind velocity for a given locality, and is explained in the next subdivision of this chapter.

TABLE 40. INFILTRATION THROUGH DOUBLE-HUNG METAL SASH WINDOWS PER FOOT OF CRACK

	WIND VELOCITY MILES PER HOUR	NON-WEATHERSTRIPPED WINDOW, LOCKED			NON-WEATHERSTRIPPED WINDOW, UNLOCKED			WEATHERSTRIPPED WINDOW, UNLOCKED		
		Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0–70 Deg. Fahr.	Equivalent Steam Radiation Sq. Ft.[a]	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0–70 Deg. Fahr.	Equivalent Steam Radiation Sq. Ft.[a]	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0–70 Deg. Fahr.	Equivalent Steam Radiation Sq. Ft.[a]
PART I Values actually determined by tests	5.0	25.0	31.5	0.13	25.5	32.1	0.13	8.1	10.2	0.04
	10.0	56.8	71.5	0.30	59.1	74.4	0.31	23.2	29.2	0.12
	15.0	88.0	110.8	0.46	92.5	116.8	0.49	39.4	49.6	0.21
	20.0	120.4	151.8	0.63	129.7	163.4	0.68	57.5	72.4	0.30
	25.0	156.3	197.0	0.82	171.4	216.0	0.90	75.3	94.9	0.40
	30.0	192.2	242.2	1.01	213.0	268.7	1.12	95.0	119.9	0.50
	35.0	233.8	294.9	1.23	265.0	334.3	1.39	118.1	148.8	0.62
PART II Values for practical use; average test values reduced by 20 per cent to allow for building up of pressure in room, etc.	5.0	20.4	25.7	0.10	20.4	25.7	0.10	6.5	8.2	0.03
	10.0	45.4	57.2	0.24	47.3	59.6	0.25	18.6	23.4	0.10
	15.0	70.4	88.6	0.37	74.0	93.1	0.39	31.5	39.7	0.17
	20.0	96.3	121.2	0.51	103.8	130.7	0.55	46.0	57.9	0.24
	25.0	125.0	157.6	0.66	137.1	172.8	0.72	60.2	75.8	0.32
	30.0	153.8	193.4	0.81	170.4	215.0	0.90	76.0	95.6	0.40
	35.0	186.8	236.0	0.98	212.0	267.5	1.11	94.5	119.0	0.50

[a] Based on heat emission of 240 B.t.u. per sq. ft.

Table 41. Infiltration through Rolled Section Steel Windows[a-c]

Per Foot of Crack of Ventilating Sash

	Wind Velocity Miles per Hour	Industrial Pivoted 1/16 in. Crack			Architectural Projected 3/64 in. Crack			Residential Casement 1/32 in. Crack			Heavy Casement Section Projected 1/32 in. Crack		
		Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0-70°F.	Equivalent Steam Radiation Sq. Ft.[b]	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0-70°F.	Equivalent Steam Radiation Sq. Ft.[b]	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0-70°F.	Equivalent Steam Radiation Sq. Ft.[b]	Leakage Cu. Ft. per Hour	Heat Loss B.t.u. per Hour 0-70°F.	Equivalent Steam Radiation Sq. Ft.[b]
PART I Values actually determined by Laboratory tests.	5	65	82	0.34	25	32	0.13	17	21	0.09	10	13	0.05
	10	135	170	0.71	65	82	0.34	40	50	0.21	30	38	0.16
	15	220	278	1.16	110	139	0.58	65	82	0.34	47	59	0.25
	20	305	384	1.60	145	183	0.76	95	120	0.50	68	86	0.36
	25	380	479	2.00	190	239	1.00	125	158	0.66	90	113	0.47
	30	465	586	2.44	260	328	1.37	160	202	0.84	120	151	0.63
PART II Values for practical use; test values reduced 20 per cent to allow for building up of pressure in room, etc.	5	52	66	0.27	20	26	0.10	14	17	0.07	8	10	0.04
	10	108	136	0.57	52	66	0.27	32	40	0.17	24	30	0.13
	15	176	222	0.93	88	111	0.46	52	66	0.27	38	47	0.20
	20	244	307	1.28	116	146	0.61	76	96	0.40	54	69	0.29
	25	304	383	1.60	152	191	0.80	100	126	0.53	72	90	0.38
	30	372	469	1.95	208	262	1.10	128	162	0.67	96	121	0.50

[a] With reasonable care in installation, leakage at contacts where windows are attached to steel framework, and at mullions, is negligible. With 3/64 in. crack, representing poor installation, leakage at contact with steel framework is about one-third, and at mullions about one-sixth, of that given for industrial pivoted windows above.

[b] Based on heat emission of 240 B.t.u. per sq. ft.

[c] Taken from *Weathertightness of Rolled Steel Windows*, by Emswiler and Randall (Journal, A. S. H. V. E., Vol. 34, No. 6, June, 1928).

TABLE 42. INFILTRATION THROUGH A HOLLOW METAL VERTICALLY PIVOTED STEEL WINDOW, INSTALLED IN A BUILDING[a]

WIND VELOCITY MILES PER HOUR	LEAKAGE CU. FT. PER HOUR PER FOOT OF CRACK	HEAT LOSS B.T.U. PER HOUR 0–70 DEG. FAHR.	EQUIVALENT STEAM RADIATION SQ. FT.[b]
5	29.5	37	0.15
10	88.5	112	0.47
15	144.5	182	0.76
20	186.0	234	0.98
25	221.5	279	1.16
30	242.0	305	1.27

[a] From *Air Leakage Through Pivoted Metal Windows*, by Houghten and McConnell (JOURNAL, A. S. H. V. E., Vol. 34, No. 7, July, 1928).

[b] Based on heat emission of 240 B.t.u. per sq. ft.

Wind movement involves both *direction* and *velocity*, and hence after transmission and infiltration losses have been computed, using coefficients which allow for average velocity, a further allowance must be made for the direction of the prevailing wind in any given locality. This shall be done by adding 15 per cent to the wall and glass transmission losses and the infiltration losses on the sides of the building exposed to the prevailing winds. Those walls which lie in the two adjacent sides of the building most nearly facing the prevailing wind are to be considered in making this correction. This is not necessarily the same as adding 15 per cent to the total heat loss of a room on the exposed sides of the building.

HEAT SOURCES

Heat Available from Sources other than Heating Plant

The heat supplied by persons, lights, motors and machinery should always be ascertained in the case of theaters, assembly halls, and industrial plants, but allowances for such heat sources must be made only after careful consideration of all local conditions. In many cases, these heat sources should not be allowed to affect the size of the installation at all, although they may have a marked effect on the operation and con-

TABLE 43. HEAT GIVEN UP BY PERSONS AND LIGHTS

[a]PERSONS:

Man at rest	400 B.t.u. per hr.
Man at work	500 B.t.u. per hr.

LIGHTS:

Electric lamps. B.t.u. per hr. equals watts per lamp × number of lamps × 3.415

Gas lighting:

1 cu. ft. producer gas	150 B.t.u.
1 cu. ft. illuminating gas	700 B.t.u.
1 cu. ft. natural gas	1,000 B.t.u.

A WELSBACH BURNER AVERAGES 3 CU. FT. OF GAS PER HOUR AND A FISH TAIL BURNER 5 CU. FT. PER HOUR.

[a] For more detailed information see Table 44, Heat Emitted by Persons per Hour at Different Room Temperatures.

trol of the system later. In general, it is safe to say that where audiences are involved, the heating installation must have sufficient capacity to bring the building up to the stipulated inside temperature before the audience arrives. In industrial plants, quite a different condition exists, and heat sources, if they are always available during the period of human occupancy, may be substituted for a portion of the heating installation. In no case should the actual heating installation (exclusive of heat sources) be reduced below that required to maintain at least 40 deg. fahr. in the building. The following allowances may be made when required:

TABLE 44. HEAT EMITTED BY PERSONS PER HOUR AT DIFFERENT ROOM TEMPERATURES

H = Heat emitted by man at rest per hour.
Hl = Heat emitted by man at light labor per hour.
Ha = Heat emitted by man at average labor per hour.
Hh = Heat emitted by man at hard labor per hour.
$H\ E$ = Heat Energy $= \left(\frac{\text{Foot-Pounds per hour}}{778}\right)$ = 84 B.t.u., 168 B.t.u. and 252 B.t.u. respectively for light, average and hard labor.
T = Room Temperature.

$H = 13.2\ (98.6 - T)$ Heat due labor $= \frac{T \times H\ E}{100}$

Hl, Ha, or $Hh = 13.2\ (98.6 - T)$ plus $\frac{T \times H\ E}{100}$

ROOM TEMP. DEG. FAHR.	REST	HEAT EMITTED BY MAN[a] B.T.U. PER HOUR AT			CONDITION REQUIRED TO BALANCE EXCESS AND SHORTAGE IN HEAT EMISSION
		84 B.t.u. Light Labor	168 B.t.u. Average Labor	252 B.t.u. Hard Labor	
30	905	931	954	981	Increasing Humidity.
40	773	807	838	874	Heavy Clothing for Reduction or Prevention of Radiation.
50	642	684	723	768	
60	509	559	606	660	
68	404	461	518	575	Normal Condition.
70	378	436	491	554	
75	312	375	438	501	Decreasing Humidity.
80	246	313	375	447	Air Currents for Producing Evaporation of Perspiration.
85	180	251	322	394	
90	114	189	259	342	

[a]For children use one-half of table values.

Motors and the machinery which they drive, if both are located in the room, convert all of the electrical energy supplied into heat, which is retained in the room if the product being manufactured is not removed until its temperature is the same as the room temperature.

If power is transmitted to the machinery from the outside, then only the heat equivalent of the brake horsepower supplied is used. In the first case the B.t.u. supplied per hour $= \frac{\text{Motor horsepower}}{\text{Efficiency of motor}} \times 2{,}546$, and in the second case B.t.u. per hr. = b.hp. × 2,546, in which 2,546 is the B.t.u. equivalent of 1 hp. hour. In high-powered mills this is the chief source of heating and is frequently sufficient to overheat the building even in zero weather, thus requiring cooling by ventilation the year round.

For intermittent heating allow 10 per cent additional for rooms heated in the day time only, and for longer intervals of several days or more, add 25 per cent in determining minimum heating requirements, and size of plant.

EXAMPLES OF HEAT LOSS COMPUTATIONS

FACTORY BUILDING. (See Fig. 9).

1. LOCATION.......... Philadelphia, Pa.
2. LOWEST OUTSIDE TEMPERATURE. (Table 3).......... -6 deg. fahr.
3. BASE TEMPERATURE:

   In this example a design temperature 10 deg. fahr. above lowest on record instead of 15 deg. fahr. is used. Hence the base temperature $= (-6 + 10) = +4$ deg. fahr.

4. DIRECTION OF PREVAILING WIND (during Dec., Jan., Feb.).......... Northwest
5. BREATHING-LINE TEMPERATURE (5 ft. from floor).......... 60 deg. fahr.
6. INSIDE AIR TEMPERATURE AT ROOF:

   The air temperature just below *roof* is higher than at the breathing line. Height of roof is 16 ft., or it is $16 - 5 = 11$ ft. above breathing line. Allowing 2 per cent per foot above 5 ft., or $2 \times 11 = 22$ per cent, makes the temperature of the air under the roof $= 1.22 \times 60 = 73.3$ deg. fahr.

7. INSIDE TEMPERATURE AT WALLS:

   The air temperature at the mean height of the *walls* is greater than at the breathing line. The mean height of the walls is 8 ft. and allowing 2 per cent per foot above 5 ft., the average mean temperature of the walls is $1.06 \times 60 = 63.6$ deg. fahr. By similar assumptions and calculations, the mean temperature of the *glass* will be found to be 64.2 deg. fahr. and that of the *doors* 61.2 deg. fahr.

8. AVERAGE WIND VELOCITY (Table 3).......... 11.0 miles per hour
9. OVERALL DIMENSIONS (See Fig. 9).......... 120 x 50 x 16 ft.
10. CONSTRUCTION:

    Walls—12-in. brick, with ½-in. plaster applied directly to inside surface.
    Roof—3-in. stone concrete and built-up roofing.
    Floor—5-in. stone concrete on 3-in. cinder concrete on dirt.
    Doors—One 12 ft. x 12 ft. wood door (2 in. thick) at each end.
    Windows—Fifteen, 9 ft. x 16 ft. single glass double-hung windows on each side.

11. TRANSMISSION COEFFICIENTS:

    Walls—(Table 12).......... $U = 0.277$
    Roof—(Table 32).......... $U = 0.610$
    Floor—(Table 31).......... $U = 0.521$
    Doors—(Table 36).......... $U = 0.382$
    Windows—(Table 36).......... $U = 1.13$

12. INFILTRATION COEFFICIENTS:

    Windows—Crack assumed $\frac{1}{16}$ in. The leakage per foot of crack for an 11-mile wind velocity is 92.7 cu. ft. per hour, for a plain window. (By interpolation from Table 39, Part II.) The heat equivalent per hour per degree is

    $$92.7 \times 0.075 \times 0.24 = 1.67 \text{ B.t.u.}$$

    Doors—Assume infiltration loss through door crack twice that of windows or

    $$2 \times 1.67 = 3.34 \text{ B.t.u.}$$

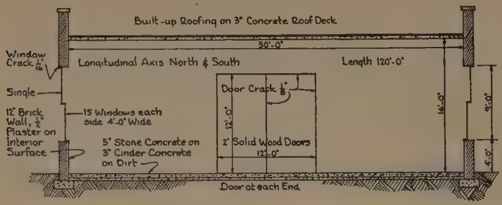

Built-up Roofing on 3" Concrete Roof Deck
50'-0"
Window Crack 1/16"
Longitudinal Axis North & South
Length 120'-0"
Door Crack ⅛"
Single
12" Brick Wall, ½" Plaster on Interior Surface
15 Windows each side 4'-0" Wide
12'-0"
16'-0"
9'-0"
4'-0"
5" Stone Concrete on 3" Cinder Concrete on Dirt
2" Solid Wood Doors
12'-0"
Door at each End

FIG. 9. ELEVATION OF FACTORY BUILDING

TABLE 45. CALCULATION SHEET SHOWING METHOD OF ESTIMATING HEAT LOSSES OF BUILDING SHOWN IN FIG. 9

PART OF BUILDING	EXPOSURE	WIDTH IN FEET	HEIGHT IN FEET	NET SURFACE AREA OR CRACK LENGTH	COEFFICIENT	TEMP. DIFF.	NET B.T.U.	EXPOSURE FACTOR	TOTAL B.T.U.
Brick, ½ in. plaster	N	50	16	656	0.277	59.6	10,820	1.15	12,460
Doors (2 in. Wood)	N	12	12	144	0.382	57.2	3,150	1.15	3,620
⅛ in. Crack	N	1 pair doors		60	3.34	57.2	11,440	½[a] x 1.15	6,580
Brick, ½ in. plaster	W	120	16	1380	0.277	59.6	22,800	1.15	26,200
Glass, (Single)	W	15 x 4	9	540	1.13	60.2	36,800	1.15	42,400
1/16 in. Crack	W	Double Hung Windows (15)		450	1.67	60.2	45,200	½[a] x 1.15	26,000
South Wall	Same as N	See Above						½[a]	19,690
East Wall	Same as W	See Above						½[a]	82,200
Roof, 3 in. Concrete and Slag-surfaced built-up roofing.	No Ceiling	50	120	6000	0.610	69.3	254,000	None	254,000
Floor, 5 in. Stone Concrete on 3 in. Cinder Concrete.	On Dirt	50	120	6000	0.521	5	15,630	None	15,630
GRAND TOTAL of heat required for building in B.t.u. per hour at +4 deg. with 11-mile northwest wind									488,780

[a] *Notes.*—(1) This building has no partitions and whatever air enters through the cracks on the windward side must leave through the cracks on the leeward side. Therefore, only one-half of the total crack will be used in computing infiltration for each side and each end of building.

(2) An exposure allowance of 15 per cent is also to be added to the wall and glass transmission losses and to the infiltration losses on the two adjacent sides of the building most nearly facing the prevailing wind as stated in the first paragraph on page 73.

(3) It is also possible to compute the heat required to take care of infiltration on the basis of half of an air change per hour as given in Table 38 for a factory with minimum conditions. Volume = 50 × 120 ×16 = 96,000 cu. ft. and heat required per hour is

$$96{,}000 \times \tfrac{1}{2} \times 0.075 \times 0.24 \times 59.6 = 51{,}500 \text{ B.t.u.}$$

Based on infiltration through one-half the total crackage in all walls, the heat to be supplied per hour is from Table 45

$$6{,}580 + 26{,}000 + 5{,}720 + 22{,}600 = 60{,}900 \text{ B.t.u.}$$

The value based on crackage should be used, but if building is to be heated intermittently, not less than one air change per hour should be allowed.

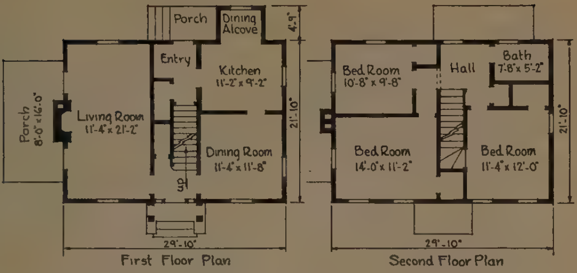


FIG. 10. FLOOR PLAN OF SIX-ROOM RESIDENCE[a]

[a] Plan 6-F-3, Architects Small House Service Bureau.

13. CALCULATIONS:

See calculation sheet, Table 45.

RESIDENCE (See Fig. 10)

1. LOCATION....................Chicago, Ill.
2. LOWEST OUTSIDE TEMPERATURE (Table 3)....................$-$ 23 deg. fahr.
3. BASE TEMPERATURE....................$(-23 + 15) = -8$ deg. fahr.
4. DIRECTION OF PREVAILING WIND (during Dec., Jan., Feb., Table 3)........Southwest
5. INSIDE TEMPERATURE....................70 deg. fahr.
6. TEMPERATURE DIFFERENCE (item 5 $-$ item 3)....................78 deg. fahr.
7. AVERAGE WIND VELOCITY (during Dec., Jan., Feb., Table 3)......17 miles per hour
8. CONSTRUCTION:

Walls—Wood siding, building paper, wood sheathing, studding, wood lath and plaster.

Roof—Wood shingles on 1 x 4 strips spaced 2 in.

Attic Ceiling—Wood lath and plaster on roof rafters

First Floor (over basement)—Maple flooring on rough flooring on floor joists

Doors (outside)—Three, 3 ft. x 7 ft. x 1¾ in.; one, 2 ft. 8 in. x 7 ft. x 1¾ in. No weatherstripping

Windows—Double-hung, single glass, weatherstripped.

9. TRANSMISSION COEFFICIENTS:

Walls—(Table 24)....................$U = 0.263$
Roof (including attic ceiling)—(Table 34)....................$U = 0.285$
Floor (over basement)—(Table 29)....................$U = 0.339$
Doors—(Table 36)....................$U = 0.421$
Windows—(Table 36)....................$U = 1.13$

10. INFILTRATION COEFFICIENTS:

Windows—The leakage per foot of crack for weatherstripped, double-hung, wood sash windows is 27.9 cu. ft. per hour for a 17-mile wind velocity. (By interpolation from Table 39, Part II.) The heat equivalent is

$$27.9 \times 0.075 \times 0.24 = 0.5 \text{ B.t.u. per hour per foot of crack.}$$

Doors—Assume $\frac{1}{16}$ in. crack. Leakage = 139 cu. ft. per hour. (Table 39, Part II). The heat equivalent is

$$139 \times 0.075 \times 0.24 = 2.50 \text{ B.t.u. per hour per foot of crack.}$$

11. Calculations:

See summary of heat loss calculations, Table 46-*A*, and heat loss calculation sheet for living room, Table 46-*B*.

Table 46-A. Summary of Heat Loss Calculations for Residence Shown in Fig. 10

Room or Space No.	Room	Glass Transmission Losses	Other Transmission Losses	Infiltration Losses	Total
1	Living Room	7,100	9,040	8,970	25,110
2	Dining Room	2,640	4,640	742	8,022
3	Kitchen	1,060	3,300	663	5,023
4	Dining Alcove	1,370	3,718	807	5,895
5	Entry	1,888	1,312	4,320	7,520
6	Vestibule	1,854	1,436	3,900	7,190
7	Bedroom (A) and Closet	3,773	3,558	1,445	8,776
8	Bedroom (B) and Closet	3,960	4,070	1,445	9,475
9	Bedroom (C) and Closet	2,900	3,765	1,660	8,325
10	Upstairs Hall	1,450	920	1,660	4,030
11	Bath	1,450	1,940	1,660	5,050
12	Attic (heated)	3,040	28,021	1,125	32,186
Grand Total of heat required for building in B.t.u. per hour at −8 deg. with a 17-mile southwest wind					126,602

Table 46-B. Heat Loss Calculation Sheet for Living Room (Fig. 10)

Part of Building	Exposure	Net Surface Area or Crack Length	Coefficient	Temp. Difference	Net B.t.u.	Exposure Factor	Total B.t.u.
Wall	E	75.6	0.263	78	1,550		1,550
Glass	E	15.0	1.13	78	1,320		1,320
Crack 1/16 in.[a]	E	19.0	0.5	78	(742)[d]		
Wall[b]	S	127.6	0.263	78	2,620	1.15	3,010
Doors	S	42.0	1.13[c]	78	3,710	1.15	4,260
Crack 1/16 in.	S	40.0	2.50	78	7,800	1.15	8,970[d]
Wall	W	75.6	0.263	78	1,550	1.15	1,780
Glass	W	15.0	1.13	78	1,320	1.15	1,520
Crack 1/16 in.[a]	W	19.0	0.50	78	(742)[d]		
Floor	Over Basement	241.0	0.339	33[e]	2,700		2,700
Grand Total of heat required for room in B.t.u. per hour at −8 deg. with a 17-mile southwest wind							25,110

[a] Windows weatherstripped.

[b] Chimney figured as part of wall, that is, of the same construction.

[c] Transmission coefficient taken same as glass for entire door.

[d] Three sides of this room are exposed and therefore only the wall having the greatest infiltration loss is used in estimating the total leakage for the room. If the infiltration loss for the south side of the room containing the two outside doors had been less than half the total infiltration loss for the room, then half the total leakage would have been used.

[e] Air temperature at floor assumed 65 deg. fahr. Air temperature in basement assumed 32 deg. fahr.

PREVENTION OF CONDENSATION ON INTERIOR BUILDING SURFACES

Condensation on the interior surface of buildings is often a serious problem. Water dripping from a ceiling may cause irreparable damage to manufactured articles and machinery. It often results in short-circuiting of electric power and lighting systems, necessitating shut-downs and incurring costly repairs. It also causes rotting of wood roof structures, corrosion of metal roofs, and spalling and disintegration of gypsum and other types of roof decks not properly protected.

Condensation is caused by the contact of the warm humid air in a building with surfaces below the dew-point temperature, and can be remedied in two ways, (1) by increasing the temperature of such surfaces above the dew-point temperature, or (2) by lowering the humidity.

Dehumidification, of course, is not permissible where a high relative humidity is necessary for manufacturing processes. Hence, the only alternative is to increase the surface temperature by decreasing the inside surface resistance. This can be accomplished by increasing the velocity of air passing over the surface, or by increasing the overall resistance of the wall or roof by installing a sufficient thickness of insulation.

The latter method is generally used, and the thickness of insulation is determined by ascertaining the amount of resistance to be added to increase the temperature of the interior surface above the dew-point temperature for the maximum conditions involved. This in turn is based on the fundamental principle that the drop in temperature is proportional to the resistance.

The thickness of insulation required to prevent condensation on the interior surface of a wall or roof can be determined by means of the following formula:

$$x = k\left[\frac{t - t_o}{f_i\,(t - t_d)} - \frac{1}{U}\right] \qquad (17)$$

where

x = thickness in inches of insulation to prevent condensation.

k = conductivity of insulation in B.t.u. per hour per square foot per degree fahrenheit per inch thickness.

U = coefficient of transmission of uninsulated wall or roof in B.t.u. per hour per square foot per degree fahrenheit.

f_i = conductance of interior surface of wall or roof in B.t.u. per hour per square foot per degree fahrenheit.

t = dry-bulb temperature of air near wall or roof surface.

t_d = dew-point temperature of air near wall or roof surface.

t_o = minimum outside temperature (usually taken as 15 deg. above lowest temperature on record for locality of building).

Example showing Use of Condensation Formula

The following example will illustrate the use of this formula:

Determine the thickness of insulation required to prevent ceiling condensation on a roof constructed of 1-in. yellow pine sheathing covered with built-up roofing for an inside temperature at the ceiling of 85 deg.

fahr., a relative humidity of 70 per cent, and an outside temperature of −10 deg. fahr., assuming the conductivity of the insulation to be 0.30 B.t.u. per hour per square foot per degree fahrenheit per inch thickness:

k = 0.30 B.t.u. per hour per square foot per degree fahrenheit per inch thickness.
t = 85 deg. fahr.
t_o = −10 deg. fahr.
$R.H.$ = 70 per cent.
t_d = 74 deg. fahr.
f_i = 1.34 B.t.u. per hour per square foot per degree fahrenheit (average, Table 4)
U = 0.485 B.t.u. per hour per square foot per degree fahrenheit (Table 32)

$$x = 0.30\left[\frac{85-(-10)}{1.34\,(85-74)} - \frac{1}{0.485}\right]$$
$$= 1.3 \text{ in.}$$

Condensation Chart

The chart (Fig. 11) can be used for approximating the thickness of insulation required to prevent condensation on the interior wall or roof surfaces of a building. The procedure for using this chart is as follows:

1. Locate the dry-bulb temperature t of the air near the ceiling on scale A, and pass horizontally to the proper relative humidity curve indicated on scale B.
2. From this point pass vertically downward.
3. Locate the difference between the temperature of the air at the ceiling and the lowest outside temperature on scale D, and draw a line horizontally until it intersects line *2*. (The vertical line drawn as per paragraph 2).
4. From the intersection of lines *2* and *3* draw a line to the point P in the lower left hand corner of the chart.
5. From the intersection of line *4* and line AB, draw a line horizontally until it intersects the diagonal line corresponding to the heat transmission coefficient of the uninsulated roof shown on scale F.
6. From the intersection found as per paragraph 5, draw a line vertically downward.
7. Locate the conductivity of the insulation to be used (expressed in B.t.u. per hour per square foot per degree fahrenheit) on scale G and draw a line to point Q.
8. From the intersection of lines *6* and *7*, draw a line horizontally to the left, and the correct thickness of insulation to use will be indicated on scale H.

Although this chart is intended primarily for roofs, it can be used for walls by taking the dry-bulb temperature and the corresponding relative humidity of the air near the walls at the point which will necessitate the maximum heat resistance to prevent condensation, instead of using the temperature and humidity near the ceiling.

Example showing Use of Condensation Chart

Determine the thickness of insulation required to prevent ceiling condensation for the following conditions:

Dry-bulb temperature near ceiling	85 deg. fahr.
Relative humidity	70 per cent
Lowest outside temperature	−10 deg. fahr.
Construction of uninsulated roof	1 in. yellow pine sheathing and built-up roofing.
Coefficient of transmission of roof	0.485
Conductivity of insulation to be used	0.30

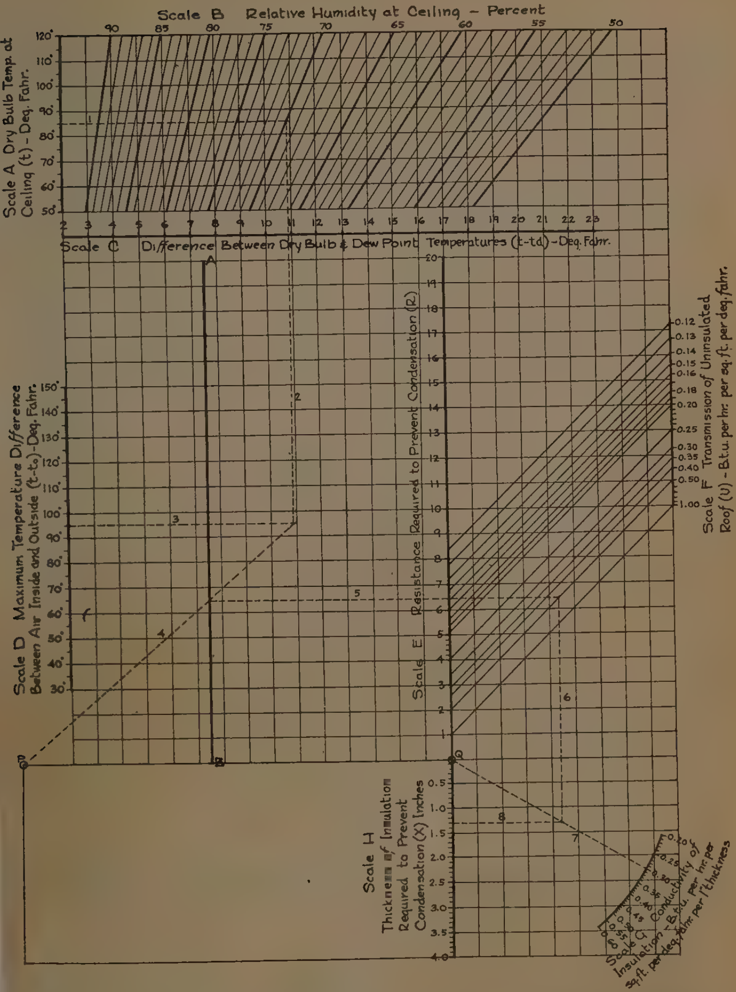


FIG. 11. CHART FOR DETERMINING THICKNESS OF INSULATION REQUIRED TO PREVENT CONDENSATION

The solution of this problem is indicated on the chart (Fig. 11) by the dotted line:

1. Locate the inside dry-bulb temperature of 85 deg. on scale *A*, and draw a line horizontally to the 70 per cent relative humidity curve, indicated on scale *B*.

2. Draw line *2* vertically downward from the intersection located as per paragraph 1.

3. Locate on scale *D* the temperature difference of 95 deg. between the ceiling temperature of 85 deg. and the lowest outside temperature of −10 deg., and draw a line horizontally until it intersects with line *2*.

4. From the point of intersection of lines *2* and *3*, draw a line to the point *P*.

5. From the intersection of lines *4* and *AB*, draw a line horizontally until it intersects with the diagonal line corresponding to a coefficient of transmission of the roof of 0.485, located on scale *F*.

6. From the intersection found as per paragraph 5, draw line *6* vertically downward.

7. Locate the conductivity of 0.30 B.t.u. per hour per square foot per degree fahrenheit of the insulation on scale *G* and draw a line to point *Q*.

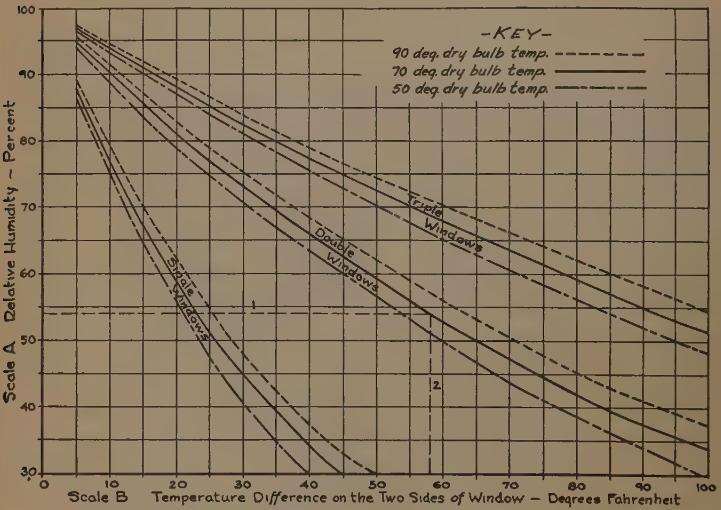


Fig. 12. Saturation Curves showing Relationship between Relative Humidity and Temperature Difference for Single, Double and Triple Windows

8. From the intersection of lines *6* and *7*, draw a line horizontally to scale *H*, on which the thickness of insulation of this conductivity is indicated, which is 1.3 in. The nearest commercial thickness above 1.3 in. would, of course, be selected.

Condensation on Windows

Fundamentally, the problem of preventing condensation on windows is no different than that of preventing condensation on walls and windows. However, it is not economical to decrease the inside surface resistance by blowing air against the window, as this increases the overall transmission. Hence, if it is necessary that a high relative humidity be maintained, the only practical method by which condensation can be prevented or reduced on windows is to increase the overall resistance by using two or more air spaces.

Window Condensation Chart

The chart (Fig. 12) is intended to be used for determining the number of panes of glass required to prevent condensation for certain temperature and humidity conditions, or for determining the outside temperature at which condensation will take place on the inside surface of single, double or triple glass for the humidity and temperature conditions involved.

To determine the type of glass required to prevent condensation, locate the relative humidity on scale *A*, and then locate the difference in temperature between the air on the two sides of the glass on scale *B*. The curve corresponding to the inside temperature conditions immediately above the intersection of the lines drawn from these two scales indicates the type of glass required. For example: If the relative humidity is 60 per cent (scale *A*) and the inside and outside temperatures are 70 deg. and 0 deg. respectively, the temperature difference (scale *B*) will be 70 deg. and triple-pane glass will be required to prevent condensation, as indicated by the curve immediately above the intersection of the lines drawn from scales *A* and *B*.

Because the transmission of even triple glass, with two air spaces, is relatively high as compared with a well-insulated wall or roof, and consequently the resistance small, the relative humidity that can exist in a building without condensation taking place on the glass is low. For this reason, and also because window condensation in many cases is not objectionable, no effort is made to prevent the condensation, the only precaution taken being to provide gutters under the windows to drain the water.

REFERENCES

Mechanical Equipment of Buildings, Vol. I, second edition, 1929, By Harding and Willard.

Bulletin No. 102, Engineering Experiment Station, University of Illinois.

Report of Insulation Committee, A. S. R. E. Annual Meeting, 1922, Revised to 1924.

Measuring Heat Emission in Building Structures, By P. Nicholls (TRANSACTIONS, A. S. H. V. E., Vol. 30, 1924, No. 685).

Air Leakage, By Houghten and Schraeder (TRANSACTIONS, A. S. H. V. E., Vol. 30, 1924, No. 686).

Air Leakage Around Window Panes, By C. C. Schraeder (TRANSACTIONS, A. S. H. V. E., Vol. 30, 1924, No. 704).

Data on Infiltration of Air Through Building Openings, By C. C. Schraeder (TRANSACTIONS, A. S. H. V. E., Vol. 31, 1925, No. 716).

Some Results of Heat Transmission Research, By F. B. Rowley (TRANSACTIONS, A. S. H. V. E., Vol. 32, 1926, No. 748).

Standard Test Code for Heat Transmission Through Walls, By A. P. Kratz (JOURNAL, A. S. H. V. E., Vol. 34, No. 1, January, 1928).

Economic Thickness of Building Insulation, By M. S. Wunderlich (JOURNAL, A. S. H. V. E., Vol. 34, No. 3, March, 1928).

Value of Building Insulation to Reduce Heat Losses, By E. N. Sanbern (JOURNAL, A. S. H. V. E., Vol. 34, No. 3, March, 1928).

Weathertightness of Rolled Section Steel Windows, By Emswiler and Randall (JOURNAL, A. S. H. V. E., Vol. 34, No. 6, June, 1928).

Heat Transmission Research, By Rowley, Morris and Algren (JOURNAL, A. S. H. V. E., Vol. 34, No. 7, July, 1928).

Air Leakage Through a Pivoted Metal Window, By Houghten and O'Connell (JOURNAL, A. S. H. V. E., Vol. 34, No. 7, July, 1928).

Heat Transfer Through Roofs Under Summer Conditions, By Houghten and Zobel (JOURNAL, A.S.H.V.E., Vol. 34, No. 8, August, 1928).

Effect of Frame Calking and Storm Windows on Infiltration Around and Through Windows, By Richtmann and Braatz (JOURNAL, A. S. H. V. E., Vol. 34, No. 9, September, 1928).

Frost and Condensation on Windows, By Leonhard and Grant, (JOURNAL, A. S. H. V. E., Vol. 35, No. 1, January, 1929).

Thermal Resistance of Air Spaces, By Rowley and Algren (JOURNAL, A. S. H. V. E., Vol. 35, No. 1, January, 1929).

Additional Coefficients of Heat Transfer as Measured Under Natural Weather Conditions, By Houghten, Gutberlet and Zobel (JOURNAL, A. S. H. V. E., Vol. 35, No. 2, February, 1929).

Air Infiltration Through Various Types of Brick Wall Construction, By Larson, Braatz and Nelson (JOURNAL, A. S. H. V. E., Vol. 35, No. 3, March, 1929).

Overall Heat Transmission Coefficients Obtained by Test and by Calculation, By Rowley, Algren and Blackshaw (JOURNAL, A. S. H. V. E., Vol. 35, No. 5, May, 1929).

Preventing Condensation on Interior Building Surfaces, By Paul D. Close (JOURNAL, A. S. H. V. E., Vol. 35, No. 9, 1929).

CHAPTER 3

STANDARDS OF VENTILATION

General Requirements; Air Supply; Temperature; Recirculation; Testing Methods; Instruments; Physiological Effects; Human Comfort; Comfort Charts; Comfort Zone; Humidity and Comfort.

VENTILATION is the science that treats of air in relation to human comfort, health, and efficiency. The test of good ventilation is the measure of health, comfort and efficiency derived from it.

In general, ventilation is applicable to spaces which are densely occupied by human beings, such as auditoriums, offices and school rooms, to spaces in which atmospheric contamination or over-heating would otherwise occur, as under certain industrial conditions, and to spaces in which a fixed and controlled air condition is required, as in certain manufacturing processes. The object of ventilation is to provide and maintain these desired atmospheric conditions.

GENERAL REQUIREMENTS OF VENTILATION

Proper ventilation depends upon the following factors:

1. Air Volume.
2. Air Temperature.
3. Relative Humidity.
4. Air Motion.

These four factors, in combination, contribute to what is termed "Effective Temperature."

5. Air purity, in reference to its freedom from odors, dust, bacteria, toxic gases, and other objectionable matter.
6. Air Distribution, with reference to general distribution, air movement, and freedom from drafts.
7. Psychological effects.

AIR SUPPLY FOR VENTILATION

A comparatively small quantity of air supply is required to take care of the needs of the lungs. A comparatively large quantity of air is required, however, to provide the bodily heat control necessary for the maintenance of health and comfort. In order to provide the necessary air movement and volume to provide comfort and to remove odors in spaces of considerable occupancy, the delivery by the ventilating plant of the quantities of air indicated in Table 1, has been general practice.

The resultant volumes will be found to comply with most of the existing legal requirements. It is, of course, understood that the air must be at such temperatures as to promote comfort.

See Code of Minimum Requirements for the Heating and Ventilation of Buildings, adopted by A.S.H.V.E. in 1925, edition of 1929.

Air Temperature: Overheating is detrimental to the quality of ventilation, and is believed to be one of the most objectionable conditions of civilization.

Dry-bulb temperatures for ventilated rooms are given in Chapter 2, under Inside Temperatures (p. 8).

Automatic temperature control in ventilating plants is discussed under Automatic Heat Control, Chapter 17 and under Air Conditioning and Cooling, Chapter 7.

Injurious substances, such as gases and fumes, may be of the utmost importance. These are handled usually by mechanical exhaust ventilation with effective distribution of inlets to the exhaust ducts. This phase of ventilation involves, in one way or another, nearly all of the other items.

TABLE 1. QUANTITY OF AIR REQUIRED FOR VENTILATION BASED ON SQUARE FEET OF FLOOR SPACE

TYPE OF BUILDING	ROOM	CU. FT. OF AIR PER MINUTE PER SQUARE FOOT OF FLOOR AREA
SCHOOLS	Classrooms	2.0
	Assembly Rooms	1.5
	Gymnasia	1.5
	Picture Machine Booths	1.5
	Dining Rooms	1.5
	Kitchens	2.0
	Corridors	0.5
	Wardrobes and Lockers	2.0
	Toilet, Bath, etc.	2.0
THEATERS	Seating Spaces	2.0
	Toilets, etc.	2.0
	Picture Machine Booths	2.0
HOTELS	Assembly Rooms	2.0
	Dining Rooms	1.5
	Kitchens	4.0
HOSPITALS	Wards	1.0
	Dining Rooms	1.5
	Toilets	2.0
	Kitchens	4.0

Relative humidity bears an intimate relationship to air movement and temperature. These relations are described under Physiological Effects of Ventilation in this chapter.

The effective temperature index fixes no limits for relative humidity. The practical limits, however, are 30 per cent during the winter and 60 per cent during the summer.

Air motion is important and is intimately associated with the temperature and humidity in producing Effective Temperature as discussed under Physiological Effects of Ventilation in this chapter.

Air purity or cleanliness has to do with human health, both from the standpoint of freedom from dust and other suspended substances, and from the standpoint of freedom from bacteria and other infectious media carried along with the dirt in air.

Odors are often removed by plentiful air supply and efficient distribution. In special cases this may be facilitated by other means, such as by the use of Ozone.

Air distribution within the space to be ventilated is of the utmost importance, and is closely correlated with effective temperature. When the air can be so conditioned and distributed that it may achieve maximum contact with each person in a room, the volume per person may be much less than that set forth in Table 1.

VENTILATION DESIGN

In the practical work of engineers who design mechanical ventilating systems, and of architects and owners who have to pass upon these systems, the one item which is the basis of all calculations and layouts, is the quantity of air to be handled by the ventilating system to produce the results desired. The functions of the air handled in connection with ventilated spaces are: (1) to supply the necessary oxygen for respiration; (2) to keep the dilution of objectionable substances down to the proper proportion, and (3) to maintain the proper effective air temperature.

It has been estimated that an adult at rest will breathe 0.25 cu. ft. of air per minute and exhale 0.01 cu. ft. of CO_2 in the same period, or at the rate of 0.6 cu. ft. per hour, thus removing about 5 per cent of the oxygen from the air actually breathed. This does not necessarily indicate the effect on the air in the room occupied. The same air may be rebreathed for a limited time without apparent harmful effect.

The air handled by the ventilating system may consist entirely of air taken from the outside or it may consist partly of new air and partly of recirculated air. In any duct system and in all ordinary buildings there is in any event a considerable air change due to leakage.

HEAT FROM OCCUPANTS, LIGHTS, EQUIPMENT

In a crowded place of assemblage the heat given off by the occupants, together with that given off by the lighting and power equipment, may be, and frequently is, more than the normal heat loss through the structure to the outside air, even in winter under cold climatic conditions. This means that in order to preserve an equilibrium of effective temperature the entering air must be cooler than the leaving air, so that the problem in such enclosures is usually one of cooling and ventilating, rather than one of heating and ventilating.

A typical case for winter might show about 300 B.t.u. of body heat, plus 100 B.t.u. per person from light, etc., being given up to the building against about 200 B.t.u. heat loss from the building, per person per hour. This would mean that 200 B.t.u. per person must be carried away by the ventilation.

If the flow of air is upward, or from the side, so as to bring the incoming air into direct contact with the occupants, the temperature of the incoming air should not be more than 5 deg. below the temperature of the air leaving the occupant, otherwise the conditions will be drafty and uncomfortable. Where the air is admitted through the ceiling, and the ceiling is high, the temperature difference may be slightly increased and, in some cases, the air quantity may be slightly decreased.

If a room is crowded in weather of 85 deg. outside temperature, with a relative humidity of 70 per cent, while giving each occupant 30 cu. ft. of air per minute, it may be assumed that there will be an increase of temperature of at least 5 deg. due to body heat and heat from equipment. The moisture increase, from the bodies of the occupants, may be assumed as 10 grains per minute, or 0.30 grains per cubic foot of air handled.

Under such a condition some method of air cooling will be needed to obtain satisfactory ventilation. A good air washer may reduce the temperature of the air passing through it about 70 per cent of the difference between the wet and the dry bulb temperatures. Its operation would hardly be worth while without a water supply having a temperature of 50 deg. or cooler because of increasing relative humidity with a decreasing temperature. The beneficial effect of an air washer will increase in proportion to the dryness of the outside air.

It should be understood that the example cited is an extreme case of temperature and humidity. Experience, however, shows that a supply of air which proves to be adequate for maintaining a desirable effective temperature in winter will prove inadequate for the same purpose in hot weather. While an increased volume of air supply is often of material benefit, the use of refrigeration brings the final hot-weather solution, not so much in actual temperature drop as in reduction of humidity.

When using an upward system of air supply, as through floor mushrooms, drafts will be felt often with the introduction of air at temperatures of more than 5 deg. cooler than the average room temperature. For this reason, and for the additional reasons of sanitation and control, the downward system of ventilation is more efficacious in large and densely occupied places of assemblage. The air should be brought in at a point high enough to permit of its being diffused before coming into contact with the occupants. It is always desirable, if not imperative, to prevent cool-air currents from striking the occupants from behind them.

RECIRCULATION

Where recirculation of air in ventilation work is utilized care should be taken that the recirculated air shall be suitable. Usually the air must be reconditioned by cleaning, dehumidifying and deodorizing. The saving in operating costs obtainable by recirculation of the air in ventilation systems, while very considerable, must not be obtained at the expense of quality.

The percentage of recirculated air may be varied to suit the seasonal changes so as to conserve heat in winter and refrigeration in summer.

Toilets and similar rooms and all kitchens in buildings using recirculation, should be separately, mechanically ventilated, with the exhaust in excess of the supply, in order to prevent objectionable odors from diffusing into other parts of the building. This air removal may in many cases be sufficient to insure a sufficient replacement of new air to the general recirculating system.

PSYCHOLOGICAL AND PHYSIOLOGICAL REACTIONS

The factors which may affect a person's health, comfort, or well being are: (1) temperature; (2) humidity; (3) motion of the air; (4) dustiness; (5) bacteria content; (6) odors present; (7) other injurious substances.

Temperature, humidity and motion taken together, determine the feeling of warmth and influence the elimination of body heat. They are the three most important factors in the physiological effects of the surrounding atmosphere upon the body.

Dust, bacteria, and odors may be of secondary importance when compared with the combined effect of temperature, humidity, and air motion, but they are nevertheless important factors, and must be given consideration.

The engineer who disregards the psychological factor in ventilation is, indeed, short-sighted. As in most human contacts and activities, the effect of air conditions on the mind is profound.

Consideration must always be given to the elimination of objectionable noise from machinery and to air-friction noises. It is usually helpful if the occupants of a ventilated room may visualize some indication that air is moving. It helps if they may, when they wish, place their bodies or portions thereof, in sensible air currents, to demonstrate that ventilation is in effect. Periodical or occasional temperature reductions, or increases in air movement, possibly accompanied by muscular exercises, are of great value, psychologically as well as physically.

It is a familiar fact that a room may be comfortable at one dry-bulb temperature and yet decidedly uncomfortable at another time at the same dry-bulb temperature. This fact may be due either to a change of relative humidity or to a change in air motion. A room may feel equally comfortable with different dry-bulb temperatures provided the relative humidity or air motion is varied to produce this effect. Other factors enter into this problem, such as changes of clothing (seasonal or otherwise), acclimatization, degree of activity, etc.

HOW TEMPERATURE, HUMIDITY, AND AIR MOTION AFFECT HUMAN COMFORT

The temperature sensations of the human body depend not only on the temperature of the surrounding air as registered by a dry-bulb thermometer, but also they depend upon the temperature indicated by a wet-bulb thermometer. Dry air at a relatively high temperature may feel cooler than air of considerably lower temperature with a high moisture content.

Air motion makes any moderate condition feel cooler.

Human comfort or discomfort, as regards feeling of warmth, depends largely upon the body temperature, and, therefore, upon the relation between the rate of production and dissipation of heat. By the process of metabolism heat is constantly generated within the body, which heat must be eliminated from the surface of the body and from the respiratory tract by radiation, convection and evaporation. To maintain a constant body temperature the heat loss must equal the heat produced. It is, therefore, apparent that any reduction in the elimination of heat from the body must result in a rise in temperature and a feeling of discomfort.

There are three principal factors affecting loss of body heat: (1) temperature; (2) humidity; (3) air motion.

As the temperature of the air and surrounding objects rises, the loss of heat by convection and radiation decreases. When the air temperature reaches that of the body, the loss by radiation and convection ceases. Finally, as the air temperature exceeds that of the body, heat is transferred from the air to the body.

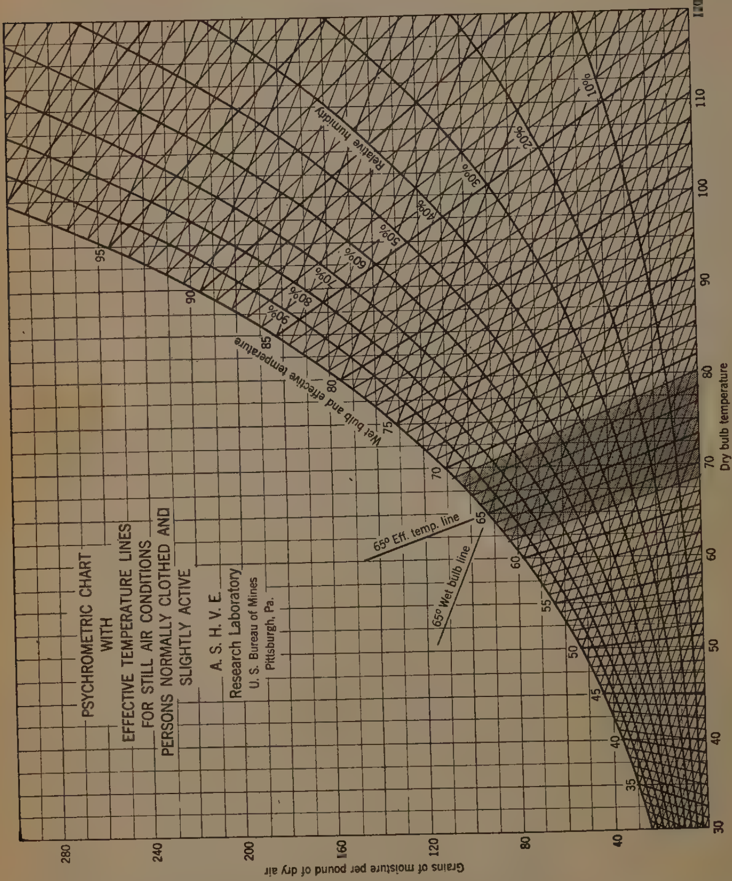


FIG. 1. PSYCHROMETRIC CHART WITH EFFECTIVE TEMPERATURE LINES FOR STILL AIR

As the temperature of the air rises and heat loss by radiation and convection decreases, the body endeavors to maintain temperature equilibrium by making available more perspiration, resulting in a greater heat loss by evaporation.

From the foregoing, it is concluded that there must necessarily exist certain combinations of temperatures and humidities, which produce the same total body heat loss by radiation, convection, and evaporation, and, therefore, the same feeling of comfort or discomfort. Lines passing through such air conditions plotted as a psychrometric chart may be called equal comfort lines. The fact is further substantiated by the general experience of heating engineers in observing that the lower the humidity the higher the dry-bulb temperature required for the same degree of comfort.

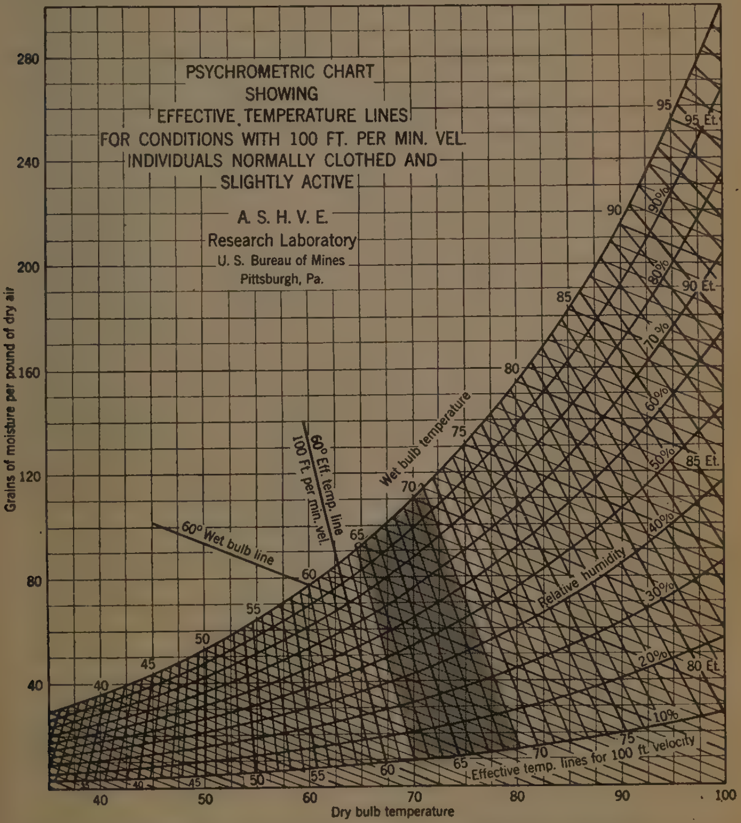


FIG. 2. PSYCHROMETRIC CHART WITH EFFECTIVE TEMPERATURE LINES FOR 100 FT. AIR VELOCITY. (SHADED AREA INDICATES THE COMFORT ZONE)

A series of tests have been made in the two psychrometric rooms of the Research Laboratory of the American Society of Heating and Ventilating Engineers in order to locate these lines on the psychrometric chart. Complete reports of these studies for both still and moving

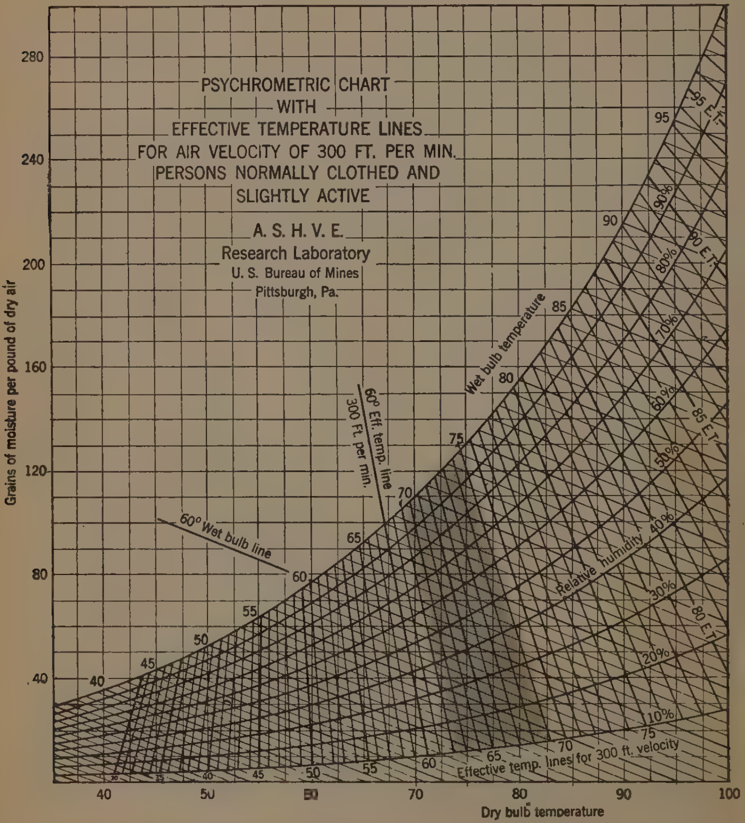


Fig. 3. Psychrometric Chart with Effective Temperature Lines for 300 ft. Air Velocity. (Shaded Area Indicates the Comfort Zone)

air are reported in the Society's Transactions, Vols., 27-32 inclusive, and in the Journals for 1926 and 1928.

The relation of temperature and humidity to comfort for persons normally clothed and at rest in still air, is given in Fig. 1, while the effect of air motion upon comfort or effective temperature for persons normally clothed is given in Figs. 2, 3 and 4.

HOW TO USE THE COMFORT CHARTS

In the Psychrometric Chart, Fig. 1, dry-bulb temperature is plotted as abscissae and grains of moisture per pound of dry air as ordinates. The maximum moisture which the air can hold at various temperatures gives the saturation, or 100 per cent relative humidity curve. Relative humidities between 0 and 100 per cent are given by a series of curved lines similar to the saturation curve. The wet-bulb temperatures for all atmospheric conditions are given by a series of nearly parallel oblique lines. Effective temperature is given by a series of oblique but not parallel lines which approach being parallel to the wet-bulb lines at high temperatures and humidities, and to the dry-bulb lines at low temperatures. The numerical values of the wet-bulb and effective temperature lines are given by the dry-bulb temperatures at their intersection with the saturation curve.

Dry-bulb temperature is the temperature of the air as determined by an ordinary dry-bulb mercury thermometer.

Wet-bulb temperature is the temperature as determined by a similar thermometer, except with its bulb encased in a fine mesh fabric bag moistened with clean water and whirled through the air until the temperature depression due to the cooling effect of evaporation from the moistened bag reaches equilibrium.

The conditions of comfort as shown by these charts are primarily for winter-time conditions in relatively cold climates, and what is hereinafter said relative to these charts pertains to such conditions. The conditions of indoor comfort corresponding to summer-time conditions or to conditions in the warmer climates are somewhat different. For data pertaining to this subject, see Inside Temperatures, Chapter 2, pp. 6 to 9.

Wet-bulb temperature corresponds to that which a thoroughly wet body will attain if the air passes over it for a sufficient length of time and with a high enough velocity. A person's body is not thoroughly wet and hence does not react entirely in accordance with either the dry or the wet-bulb temperature. At high temperatures when the body is moist with perspiration, it reacts more nearly in accordance with wet-bulb temperature; while at low temperatures when the body is comparatively dry, it reacts more nearly in accordance with the dry-bulb temperature.

Definition of Effective Temperature

Effective temperature is an experimentally determined scale which unlike the dry-bulb and wet-bulb scales is a true measure or index of a person's feeling of warmth in all combinations of temperature, humidity, and air motion. In other words, for any one given effective temperature a person will feel the same degree of warmth or coldness regardless of the dry-bulb temperature, wet-bulb temperature and velocity of the air required to produce that particular effective temperature.

The psychrometric charts for moving air (Figs. 2, 3 and 4), differ from the chart for still air (Fig. 1) only in that the effective temperature lines for any particular degree do not intersect the dry-bulb, wet-bulb or dew-point temperature lines at the same degree on the saturation or 100 per cent relative humidity curve, but are removed to the right so that the effective temperature for any dry and wet bulb temperature is lower for moving air than it is for still air. This difference between the effective temperature for still air and for moving air, of any velocity, is the cooling resulting from that velocity. The difference between the dry or wet bulb temperature and the effective temperature at saturation also gives the cooling produced by the velocity for that condition.

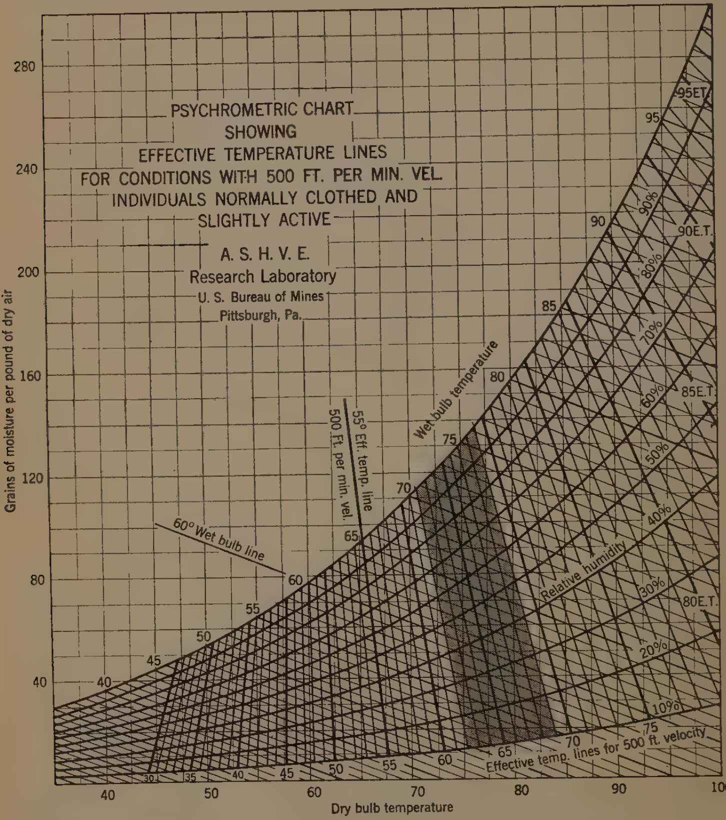


Fig. 4. Psychrometric Chart with Effective Temperature Lines for 500 ft. Air Velocity. (Shaded Area Indicates the Comfort Zone)

The psychrometric chart (Fig. 5) gives the effective temperature lines for still air and for three velocities ranging from 150 to 500 ft. per minute on the same chart. It is of value in giving at a glance the relative cooling effect of different velocities.

THE COMFORT LINE AND THE COMFORT ZONE

That range of effective temperatures over which 50 per cent of people feel comfortable, namely 62 to 69 deg. fahr. is called the *comfort zone.*

That particular effective temperature at which a maximum number of people feel comfortable is called the *comfort line.* While at rest, 97 per cent of people have been found to be comfortable at 64 deg. fahr. effective temperature. Persons working at various rates are most comfortable at effective temperatures below 64 deg. The exact effective temperatures giving maximum comfort for persons working at various rates have not yet been determined by the Research Laboratory, but from the best data available; they are as follows: at rest, 64 deg.; light work, 62 deg.; hard work, 60 deg.

The data given in the charts, Figs. 1 to 5, are for persons normally clothed and differ somewhat from the data contained in earlier editions of THE GUIDE, which data were for persons stripped to the waist.

HEAT DISSIPATED TO THE ATMOSPHERE FROM THE HUMAN BODY

The heat dissipated from the human body is a factor which must be taken into consideration in conditioning air in audience halls. Research at the Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS[1] has resulted in the data given in Figs. 6, 7, 8 and 9, which are in convenient form for practical application.

Although total heat loss and sensible and latent heat losses are not exact functions of effective and dry-bulb temperature, respectively, for all conditions of humidity and air motion, they are plotted as such in the curves. This is accomplished by approximations not always rigidly accurate, but sufficiently so for application in most practical problems.

These data are offered for the use of the engineer in solving most of his practical problems. In some instances, however, in particular cases where extreme accuracy is desired, the variation in the data for different atmospheric conditions as given in the complete laboratory report may be taken into consideration.

An atmospheric condition resulting in sensible perspiration is to be avoided for good air conditions. Table 2 gives the approximate effective temperature at which perspiration is noticeable in different degrees by most individuals for 95 per cent and 20 per cent relative humidity.

Problems Involving Heat Dissipated from Human Body

Problem 1-A: How much sensible heat, how much latent heat and how much water vapor will be added per hour to the atmosphere of an auditorium by an audience of 1,000 adults, when the dry and wet bulb temperatures are 75 deg. fahr. and 63.5 deg. fahr., respectively?

Problem 1-B: If the dry and wet bulb temperatures of the auditorium were 85 deg. and 63 deg., respectively, how much heat and moisture would be dissipated to the atmosphere?

Solution—Problem 1-A: From Fig. 7 find the sensible heat loss per person for 75 deg. dry bulb and still air to be 265 B.t.u. per hour. From Fig. 8 find the latent heat loss per person for 75 deg. dry bulb to be 134 B.t.u. per hour and the moisture added to be

---

[1] Heat and Moisture Losses from the Human Body and Their Relation to Air Conditioning Problems, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant (TRANSACTIONS, A. S. H. V. E., 1929, when published).

905 grains per hour. 1,000 × 265 = 265,000 B.t.u. sensible heat; 1,000 × 134 = 134,000 B.t.u. latent heat and 1,000 × 905 = 905,000 grains or 129 lb. of water vapor will be added per hour to the air in the auditorium.

These sensible and latent heat loss additions may also be found as follows: The effective temperature of the condition 75 deg. dry bulb and 63.5 deg. wet bulb is 70.3 deg. effective temperature. From Fig. 6 find 403 B.t.u. as the total heat added to the air by a person for 70.3 deg. effective temperature. From Fig. 9 find the percentage of sensible and latent heat at 75 deg. dry bulb to be 66.5 per cent and 33.5 per cent. The sensible heat added to the air in the auditorium is 1,000 × 0.665 × 403 = 267,995 B.t.u. per hour. The latent heat added is 1,000 × 0.335 × 403 = 135,005 B.t.u. per hour.

Solution—Problem 1-B: From Figs. 7 and 8, respectively, the sensible and latent heat losses per person for 85 deg. dry bulb are found to be 164 and 225 B.t.u. per hour. The water vapor added to atmosphere is 1,520 grains per hour. The audience will then add 164,000 B.t.u. sensible heat, 225,000 B.t.u. latent heat and 1,520,000 grains or 217 lb. of water vapor to the air in the auditorium per hour.

Problem 2: Neglecting the gain or loss of heat to an auditorium by transmission or infiltration through the walls, windows and doors, how many cubic feet of outside air, with 65 deg. dry bulb, 59 deg. wet bulb and 63.1 deg. effective temperature must be added per hour to an auditorium containing 1,000 people in order that the inside shall not exceed 75 deg. dry and 65 deg. wet bulb, respectively?

TABLE 2. CONDITION OF SENSIBLE PERSPIRATION FOR VARIOUS ATMOSPHERIC CONDITIONS [b]

DEGREE OF PERSPIRATION [a]	ATMOSPHERIC CONDITION					
	95 PER CENT R. H.			20 PER CENT R. H.		
	E. T.	D. B.	W. B.	E. T.	D. B.	W. B.
Forehead clammy	**73.0**	73.6	72.4	**75.0**	87.0	60.7
Body clammy	**73.0**	73.6	72.4	**75.0**	87.0	60.7
Body damp	**79.0**	79.7	78.4	**81.0**	97.5	67.5
Beads on forehead	**80.0**	80.8	79.4	**87.0**	109.4	75.2
Body wet	**84.5**	85.4	84.0	**86.5**	108.5	74.6
Perspiration on forehead runs and drips	**88.0**	89.0	87.6	**94.0**	125.2	85.4
Perspiration runs down body	**88.5**	89.5	88.1	**90.0**	116.0	79.5

[a] Forty per cent of subjects registered degree of perspiration equal to or greater than indicated.

[b] "Thermal Exchanges between the Human Body and its Atmospheric Environment," by F. C. Houghten, W. W. Teague, W. E. Miller, W. P. Yant (*American Journal Physiology*, Vol. 88, No. 3, April, 1929, pp. 386–406).

Solution—Problem 2: Figs. 7 and 8 give 265 B.t.u. sensible heat and 905 grains of moisture as the additions per person with 75 deg. dry bulb in the auditorium. Therefore 265,000 B.t.u. of sensible heat and 905,000 grains of moisture will be added to the air in the auditorium per hour.

Taking 0.24 as the specific heat of air, 2.4. B.t.u. per pound of air will be required to raise the dry-bulb temperature from 65 to 75 deg. and $\frac{265{,}000}{2.4} = 110{,}400$ lb. of air or 110,400 × 13.4 = 1,479,000 cu. ft. of air per hour will be required. This is equivalent to $\frac{1{,}479{,}000}{1{,}000 \times 60} = 24.7$ cu. ft. per person per minute.

The moisture content of the inside air as taken from a psychrometric chart is 76 grains per pound of dry air and that of the outside condition is 65 grains so the increase in moisture content will be 11 grains per pound of dry air. $\frac{905{,}000}{11.0} = 82{,}300$ lb. of dry air or approximately 83,000 lb. of air at the specified condition will be required. This is equivalent to 83,000 × 13.4 = 1,112,000 cu. ft. of air per hour or $\frac{1{,}112{,}000}{1{,}000 \times 60} = 18.5$ cu. ft. of air per minute per person.

The higher volume of 24.7 cu. ft. per person per minute will be required to keep the dry-bulb from rising above the 75 deg. specified. The wet-bulb will, therefore, not rise to the maximum of 65 deg.

Examples 1-A and 1-B demonstrate that while the effective temperature, and, hence, the feeling of warmth and rate of total heat loss, does not differ greatly in the two cases, the relative proportion of sensible and latent heat loss is reversed. In order to maintain the air conditions stipulated the air conditioning equipment must remove 61.6 per cent

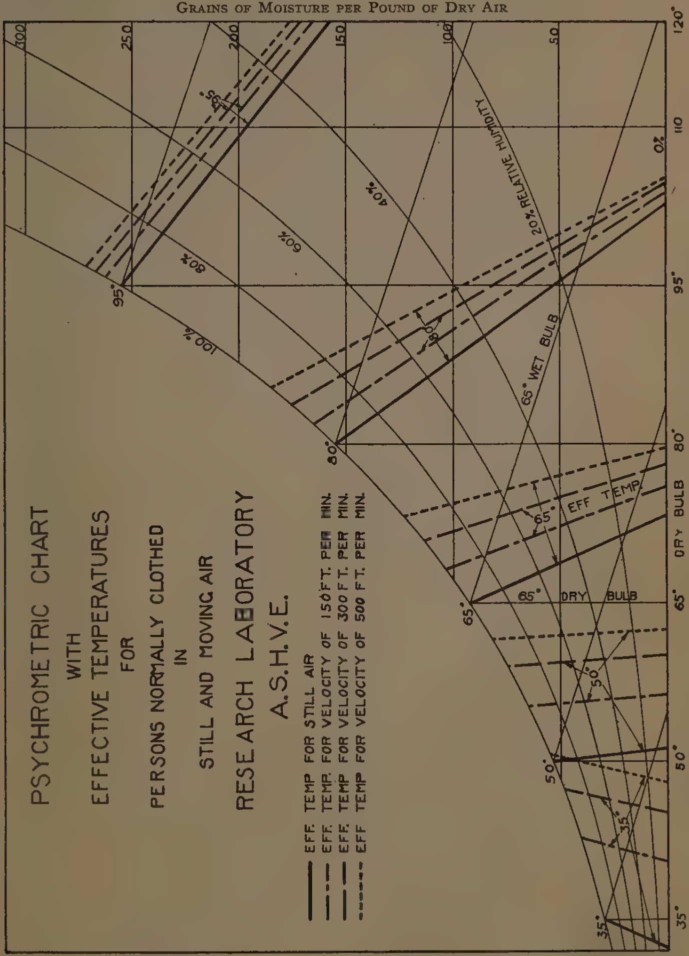


Fig. 5. Psychrometric Chart with Effective Temperature Lines for Still and Moving Air

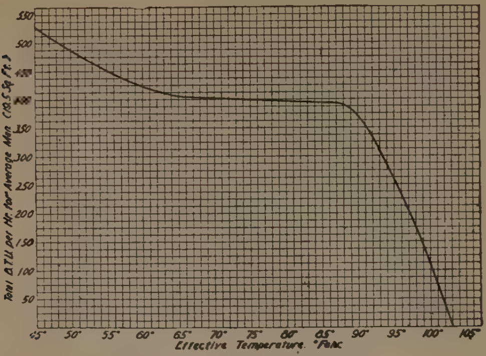


FIG. 6. RELATION BETWEEN TOTAL HEAT LOSS FROM THE HUMAN BODY AND EFFECTIVE TEMPERATURE

more sensible heat in (1-A) than in (1-B); and 67.8 per cent more latent heat or water vapor in (1-B) than in (1-A). In (1-A) 66.5 per cent of the total heat loss is sensible while in (1-B) only 42.5 per cent of the total loss is sensible.

CONDITIONING AIR FOR HUMAN COMFORT

There are four fundamental ways of producing effective cooling: (1) The dry-bulb temperature may be lowered by direct cooling or removal of heat. (2) The moisture content of the air may be reduced. (3) Air motion may produce effective cooling except for extremely severe conditions. (4) Evaporation of water without addition or subtraction of

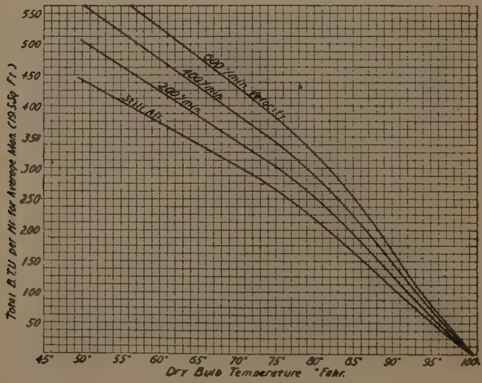


FIG. 7. RELATION BETWEEN SENSIBLE HEAT LOSS FROM HUMAN BODY AND DRY-BULB TEMPERATURE FOR STILL AND MOVING AIR

heat is accompanied by an increase in moisture content and a fall in dry-bulb temperature along the wet-bulb line resulting in effective cooling.

Take as an example a condition of 92 deg. dry bulb and 40 per cent relative humidity having a wet-bulb temperature of 72.8 deg. and effective temperature of 81.1 deg. This condition can be made equivalent to 78 deg. effective temperature or it can be made to feel 3.1 effective deg. cooler by any one of the four fundamental changes mentioned.

(1) By the removal of heat the dry bulb may be made to fall to 85.5 deg. (see Fig. 1) along the "90 grain moisture per pound of dry air" or 64.2 deg. dew-point line when the effective temperature will be 78 deg.

(2) Without removal of sensible heat or lowering of the dry bulb, the moisture content may be reduced from 90 to 44 grains per pound of dry air, when the effective temperature will be 78 deg.

(3) A 500-ft. velocity (see Fig. 4) will change the still-air condition of 81.1 deg. effective temperature to 78 deg. effective temperature or will give 3.1 deg. effective temperature cooling.

(4) Evaporation of water at room temperature without addition or removal of heat will cause the point on the chart, Fig. 1, indicated by our condition, to move along the wet-bulb line to the left thereby lowering the dry-bulb temperature and increasing the moisture content. The wet-bulb temperature will remain the same but the effective temperature will be lowered. By adding 14 grains of moisture without heat, the dry bulb will fall to 83.8 deg. and the effective temperature will fall to 78 deg.

The best method of producing effective cooling to be employed in any particular case will depend upon accompanying circumstances and should be determined by a competent engineer. Generally, the removal of heat or water vapor or both, by direct cooling or dehumidifying is most effective. Effective cooling by air motion or evaporation of water is relatively much less expensive, but these methods of cooling are limited to certain conditions of temperature and humidity. Cooling by evaporation of water is effective when the air is dry or when there is considerable difference between the wet and dry bulb temperature. Cooling by air motion is most effective at low temperatures. When the effective temperature approaches that of the body little or no cooling results and for certain higher temperatures air motion will make an uncomfortable condition even less bearable.

For moderately high temperatures greater effective cooling is experienced as the result of air motion at high humidities than at low humidities. This suggests a valuable method of cooling by a combination of evaporation and air motion. Take, for example, a condition of 96 deg. dry bulb and 80 deg. wet bulb having an effective temperature of 85.7 deg. A 300-ft. air velocity will improve this condition by only 2.2 deg. Saturation with water vapor will give a condition of 80 deg. dry bulb, 80 deg. wet bulb and 80 deg. effective temperature or 5.7 deg. effective temperature improvement. A 300-ft. air velocity with this new wet and dry bulb will give an effective temperature of 75.7 deg. or a total improvement of 10.0 deg.

For cooling produced by velocities other than those given in Figs. 2, 3 and 4 the reader is referred to the Tables and Examples on page 737 of the November, 1926, JOURNAL.

Example 1.—Given dry-bulb and wet-bulb temperature of 75 and 68 deg. First: what is the effective temperature? Second: is this condition warmer or cooler than 80 deg. dry bulb and 60 deg. wet bulb?

Answer.—The first condition is given by the intersection of the 75 deg. dry-bulb line and the 68 deg. wet-bulb line. The effective temperature is given by the numerical value of the effective temperature line passing through this point and indicated by the scale along the saturation curve, and is 71.9 deg. effective temperature. The second condition is given by the intersection of 80 deg. dry-bulb and 60 deg. wet-bulb and is 71.7 deg. effective temperature. It is therefore 0.2 deg. effective temperature cooler than the first condition.

Example 2.—Given 76 deg. dry-bulb and 61 deg. wet-bulb how many degrees difference between this condition and the comfort line or 64 deg. effective temperature?

Answer.—The effective temperature of this condition is given by the intersection of the 76 deg. dry bulb and 61 deg. wet-bulb lines and is 70 deg. effective temperature or 6 deg. effective temperature warmer than the comfort line.

Example 3.—Given the dry and wet bulb temperatures in a room 76 and 54 deg. respectively, what air velocity will be necessary to make this condition ideally comfortable, that is, 64 deg. effective temperature?

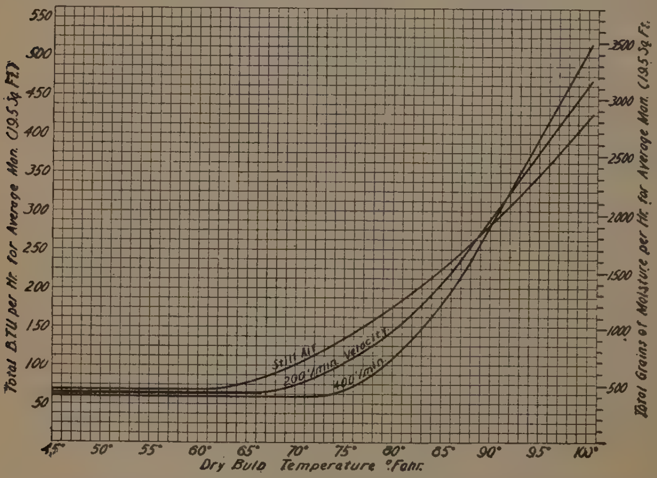


FIG. 8. RELATION BETWEEN HEAT AND WEIGHT LOSS FROM THE HUMAN BODY BY EVAPORATION AND DRY-BULB TEMPERATURE FOR STILL AND MOVING AIR

Answer.—From Fig. 1 for still air it will be seen that this condition has an effective temperature of 68.1 deg. in still air, while an air velocity of 300 ft. (see Fig. 3) gives an effective temperature of 64.7 deg. A velocity of something more than 300 ft. per minute will give the desired result. The exact velocity may be found by looking through the various tables 2 to 7, for moving air, in the JOURNAL OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, November, 1926.

Example 4.—Given a condition having dry and wet bulb temperature of 90 and 85 deg., respectively, how much cooler will this condition feel if 300 ft. air velocity is supplied instead of still air?

Answer.—From Fig. 1 it will be found that this condition in still air has an effective temperature of 86.6 deg., while if the air has 300 ft. velocity it will be found from Fig. 3 that it will have an effective temperature of 83.8 deg. Cooling of 2.8 deg. will be produced by the 300 ft. air velocity.

There are many applications for these data. In warm weather it is especially desirable to have greater comfort in school rooms, theaters, auditoriums, also factories, foundries, iron, steel and glass works, mines and other places where workers are subjected to extreme temperature conditions. Maintaining comfortable conditions indoors in summer when the temperature is about 95 deg. is a more complicated problem than maintaining the proper condition in winter.

Effective cooling, using cold water or refrigeration, is frequently resorted to in theaters and other public buildings and this practice may be expected to increase.

HOW RELATIVE HUMIDITY AFFECTS HUMAN COMFORT

Relative humidity has a bearing on the well being of man besides having an effect in determining his feeling of warmth. While its effect on health and comfort has never been thoroughly investigated, and while authorities do not agree as to reasons why a high or a low humidity is harmful, there is general agreement that very high or very low humidities indoors are to be avoided. It is generally accepted that for good ventilation the relative humidity should not be below 30 per cent or above 60 per cent.

Maintaining proper humidity indoors is particularly a problem in cold weather. The reason for this can easily be seen when one considers that most rooms have from 1 to 2 air changes per hour due to infiltration (See Table 38, Chapter 2), or that air circulates freely between the outside and inside of most buildings.

The psychrometric chart (Fig. 1) shows that one pound of dry air at 30 deg. fahr. can have a maximum of only 24 grains of moisture even if the relative humidity is 100 per cent. If this air upon coming indoors is heated to 70 deg. fahr. without addition of moisture the moisture content will still be the same, but the relative humidity will fall to 23 per cent. Likewise an outside temperature of zero with 100 per cent relative humidity will give 5.2 per cent relative humidity inside, while 20 deg. below zero outside will give 1.7 per cent inside. Air at a temperature of 70 deg. with a relative humidity of 20 per cent or lower is noticeably dry and has a great affinity for moisture and takes it rapidly from any available source, resulting in raising of dust, damage to glued furniture, and a parched or irritated condition of the mucous membrane of the outer portions of the respiratory tract. Contrary to common belief, however, the total moisture removed from the entire respiratory tract through breathing a given mass of air is practically the same indoors with 70 deg. and 5.2 per cent relative humidity as it is out-of-doors with zero and 100 per cent relative humidity.

There is likewise difference of opinions concerning the relation of high relative humidity to health and comfort. A high humidity indoors is objectionable due to precipitation on windows and other cold surfaces and a general tendency for a damp unsanitary condition to develop.

TESTING METHODS AND INSTRUMENTS

Temperatures

In the measuring of room temperatures care must be exercised to prevent the results from being affected by the body heat of the observer, by drafts from doors, windows and other openings or by radiant heat from some local source such as a radiator, wall, etc. All thermometers should be mercury thermometers with engraved stems. The total graduations of the thermometers should be from 20 to 120 deg. fahr., in one degree graduations. No ten degrees should occupy a space of less than one-half inch. The accuracy throughout the whole scale must be within one-half degree. The operator should take hold of the top and no part of the body, including the hand, should be nearer than 10 in. to the bulb. The thermometer should not be closer than 5 ft. to any door, window, or other opening; should not be closer than 12 in. to any wall, and should be between 3 and 5 ft. from the floor. A sling instrument should be used for extreme accuracy.

For measuring duct temperatures an angle-duct thermometer should be used, having a flange to bolt on the side of the duct, with the bulb extending into the duct at least 6 in.

Recording thermometers, generally have considerable lag and should not be used for the taking of temperatures for testing, but rather for giving continuous records of the operation of the plant, as the charts will indicate any lack of attention on the part of those responsible for the operation of the plant.

Humidity

The sling psychrometer is the recognized standard instrument for determining humidities. In order to obtain accurate readings considerable skill is required on the part of the operator. The wicking must be clean, distilled water should be used, and the temperature of the water should be slightly above the wet-bulb temperature of the surrounding air.

The psychrometer should be swung rapidly and two or three observations should be made to see that the wet-bulb temperature has become stationary before the final reading is noted. Standard psychrometric tables should be used.

In taking humidity readings in ducts it is usually impracticable to use a sling psychrometer. For this work the stationary hygrodeik arranged for bolting on to the side of the duct, with two bulbs extending into the duct, will be found very convenient. Due to the velocity of the air passing over the bulbs within the duct an accurate reading will be secured, corresponding to that given by the sling psychrometer.

CO_2 Determinations

At ordinary concentrations carbon dioxide is not harmful. The amount of carbon dioxide in the air is a convenient index of the rate of air supply, and of the distribution of the air within large rooms. A high carbon dioxide concentration in parts of an occupied room may indicate air stagnation which can result in objectionable odors or in failure to remove local surplus heat.

The Petterson-Palmquist apparatus has been generally accepted as the standard device for the determination of carbon dioxide in air investigations. The principle involved is the measurement of a given volume of air, the absorption of the contained carbon dioxide in a caustic potash solution, and the remeasurement of the volume of air at the original pressure in a finely graduated capillary tube, the difference in volume representing the absorbed carbon dioxide. (See Report of Committee on Standard Methods for Examination of Air, *American Public Health Asso-*

ciation, Vol. 7, No. 1; *American Journal of Public Health*, Jan., 1917).

Where field conditions are such that this apparatus may not be conveniently used, as in street cars, air samples may be collected in prepared bottles having rubber stoppers, and these may be subjected to laboratory analysis.

Dust

Atmospheric dust is of great importance in certain industrial processes, and if the dust be siliceous in nature, as from grinding stones, the hazard to health may be very serious.

The Hill Dust Counter is a simple device with which to measure the number of very large particles of dust in the air, while more exact studies of dust may be made with the Konimeter, or with the Impinger. (See *Public Health Bulletin*, No. 144, 1925, U. S. Public Health Service).

Bacteria

The number of bacteria which are attached to heavy particles of dust or drops of moisture may be determined by the number of colonies that develop on a culture plate which has been exposed for two minutes. A standard 4-in. Petrie dish, with agar-agar for a media, is used for this purpose. The plates are incubated from 24 to 48 hours at a temperature of 98 deg. fahr. At the end of this time the separate colonies have developed to a size which are easily counted. If an incubator is not available cultures may be grown at room temperatures (70 deg.) for a period of five days.

Volumetric air measurements must be made with skill and precision and great care must be exercised in securing the right conditions under which such measurements are made. There are two general methods in use for measuring air volumes, the first, by means of an anemometer, and the second, by means of a Pitot tube.

Anemometers

The anemometer, as at present obtainable, is not an authoritative instrument for quantitative measurement of air volume through a register or a duct, however useful and acceptable one may be for relative adjustment of air speed.

When it is necessary to employ an anemometer for measuring air volume, the instrument must have been recently calibrated, and the greatest care must be exercised in methods of manipulation. The influence of obstructions at the register face, the distance from the register at which the anemometer is held and the great variation in velocities which exists over the area of most air discharge openings all combine to make an exact quantitative measurement of air by an anemometer a difficult matter. (See Report on Measuring Air Velocities with the Anemometer, with discussion, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS TRANSACTIONS, 1913, Vol. 19, pp. 202 to 207).

Pitot Tubes

Measurements of air velocities exceeding 20 ft. per second should be made by means of Pitot tubes. Volumetric determinations from Pitot tube readings must take into account the barometric pressure, temperature, humidity, and the possible dust of the air. These factors determine the weight or density of the air.

In general, no accurate velocity pressure readings can be taken of any air current which is affected by changes of directions of the ducts. Accurate readings can only be taken in a duct which is straight and without turns and elbows for a distance of at least 50 times the diameter of the circular duct, or the greatest dimension of a rectangular duct. Where space conditions do not make such conditions possible, baffling or dividing the duct into numerous smaller ducts by division plates becomes necessary. (See Report on the use of the Pitot Tube, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS TRANSACTIONS, 1914, Vol. 20, p. 211, and Standard Code for the testing of Centrifugal and Disc Fans, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS TRANSACTIONS, 1923, Vol. 29, pp. 407 to 416).

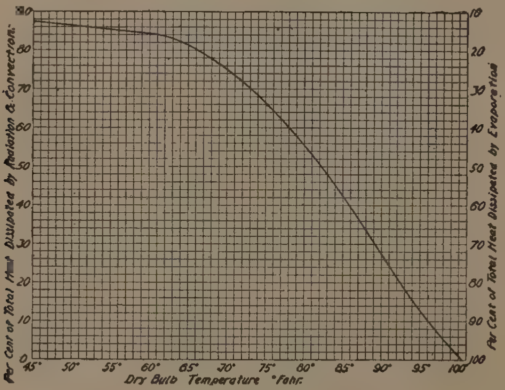


FIG. 9. RELATION BETWEEN HEAT LOSS FROM THE HUMAN BODY BY EVAPORATION, RADIATION, CONVECTION AND DRY-BULB TEMPERATURE

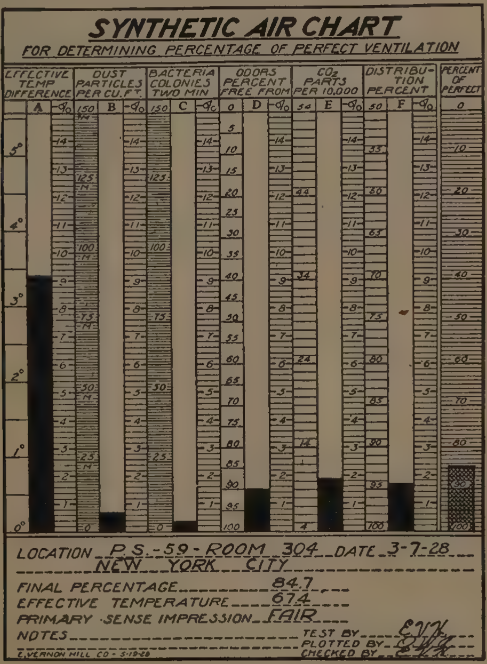
Air Movement Determinations

Air movement is a vital factor in the prevention of stagnant areas and bodily discomfort. Where a determination of air movement is desirable the Kata-thermometer, as developed by Dr. Leonard Hill, of England, may be used. (See Report of Committee on Standard Methods for Examination of Air, *American Public Health Association*, *American Journal of Public Health*, Vol. 7, No. 1, January, 1917. The wet Kata-thermometer gives the rate of cooling by radiation, convection and evaporation. The dry Kata-thermometer gives the rate of cooling by radiation and convection. The difference between the two is the rate of heat loss due solely to evaporation. Air movement is a consideration in the determination of the effective temperature.

Air movement may be determined approximately by observation of the movement of a smoke cloud and the use of a stop watch; the smoke cloud being formed by means of an ammonium chloride cloud device, or by a smoke bomb. Carefully balanced gas balloons may also be used.

SYNTHETIC AIR CHART

The form of the Synthetic Air Chart has been slightly modified since it was originally adopted by the Society and the form here presented is the one in use at the present time. (See Synthetic Air Chart, by E. Vernon Hill, Transactions, A. S. H. V. E., Vol. 23, 1917).



LOCATION P. S.-59-ROOM 304 DATE 3-7-28
NEW YORK CITY
FINAL PERCENTAGE 84.7
EFFECTIVE TEMPERATURE 67.4
PRIMARY SENSE IMPRESSION FAIR
NOTES
TEST BY E.V.H.
PLOTTED BY E.V.H.
CHECKED BY E.V.H.
E. VERNON HILL CO - 5-19-28

Fig. 10. Synthetic Air Chart

Description of the Chart

The Synthetic Air Chart is designed for measuring the air conditions maintained in a room. Instead of speaking of the ventilation of a room as good, bad or indifferent, the results of tests are plotted on a chart, and the air conditions as a whole determined on a percentage basis. (Fig. 10).

This is done by plotting test data for all known factors that make up the air conditions. These factors with their proper weights are arranged in vertical columns across the chart.

The base of each column represents ideal conditions, or 100 per cent perfect. The columns are seven in number, and the first six are indicated by the capital letters, *A*, *B*, *C*, *D*, *E*, *F*.

A = the Effective Temperature Difference, or the amount of variation from the ideal effective temperature.
B = Dust Particles per Cu. Ft.
C = Bacteria.
D = Percentage of freedom from objectionable odors.
E = Carbon Dioxide, parts per 10,000.
F = the Distribution Percent.

The last column is the Percent of Perfect column used for plotting the final percentage.

Each of these main columns is further divided into three smaller columns, the center one of which is left blank for recording the test data. To the left of this is the scale for the individual factor, effective temperatures in degrees, dust in particles per cubic foot, carbon dioxide in parts per 10,000, etc. On the right of each central column is the penalization scale. This is arranged with main graduations of 1 per cent which are numbered. Each graduation is further subdivided into fifths so that the scale may be read to 0.2 of 1 per cent on the scale, or by interpolation to 0.1 per cent.

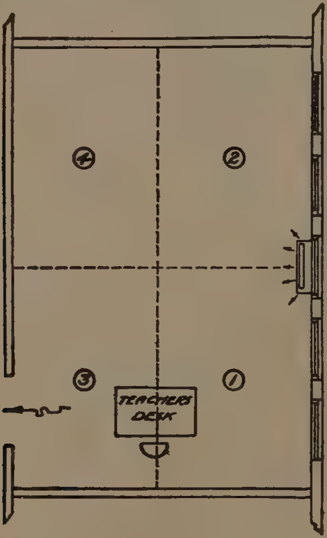


FIG. 11. STATIONS FOR MAKING TEST

The chart gives not only final percentage of the test as a whole, but also indicates at a glance which factors are satisfactory and which at fault. In this way it is a convenient guide in correcting bad conditions, and bringing the final percentage up to the point desired.

Making the Test

In making a Synthetic Air Chart test the observer first divides the room by imaginary lines into small sections, each section having an area of approximately 200 sq. ft. of floor space. He locates an observation station in the center of each section. Taking a school classroom for example, the room should first be divided into four equal rectangular areas by imaginary lines bisecting at right angles through the center of the room. (*See* Fig. 11.) Four stations are now selected, one at the center of each rectangle. These stations are numbered *1*, *2*, *3* and *4*. It is always well to use a standard method of numbering stations, so that whoever reads the report can visualize each location.

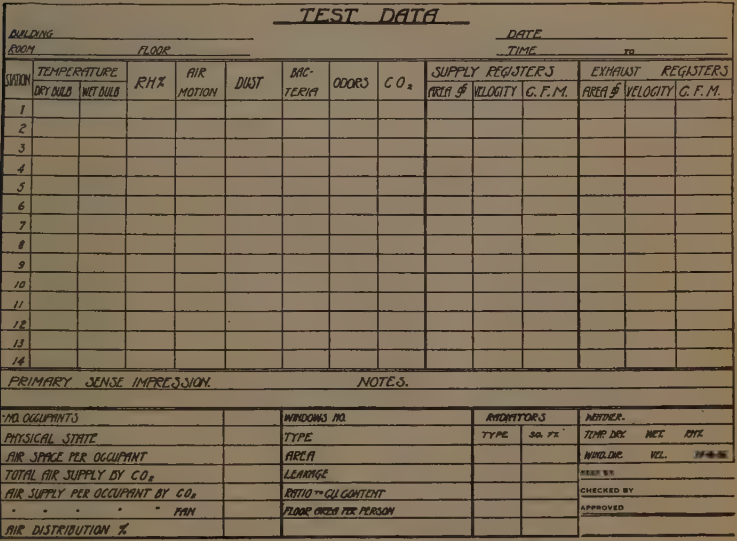
Standing at the rear of the room facing the teacher's desk *No. 1* is the station nearest the teacher at her right. *No. 2* is the one directly back of *No. 1*. *No. 3* is the station nearest the teacher at her left, and *No. 4* the remaining station.

The tests are conducted in the following manner:

Column A.—A Psychrometer reading is taken at each station beginning with *1*, following with *2, 3 and 4*. The wet and dry bulb readings are separately recorded on the data sheet (Fig. 12) for each station.

Column B.—Dust determinations are next made at stations *1, 2, 3 and 4*, and the count of particles per cubic foot recorded from each station. The scale of the chart is arranged for a direct reading dust counter. If some other type of instrument is used, a correction factor is, of course, necessary.

Column C.—Culture plates are next exposed to determine the bacterial content of the air. One plate is exposed at each station for two minutes, incubated, and the colonies that develop are counted and recorded for each plate. The average of all plates is plotted on the chart.



TEST DATA

BUILDING
DATE
ROOM FLOOR
TIME TO

STATION	TEMPERATURE		RH%	AIR MOTION	DUST	BACTERIA	ODORS	CO_2	SUPPLY REGISTERS			EXHAUST REGISTERS		
	DRY BULB	WET BULB							AREA $	VELOCITY	C.F.M.	AREA $	VELOCITY	C.F.M.
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														

PRIMARY SENSE IMPRESSION. NOTES.

NO. OCCUPANTS		WINDOWS NO.	RADIATORS		WEATHER.
PHYSICAL STATE		TYPE	TYPE	SQ. FT.	TEMP. DRY WET RH%
AIR SPACE PER OCCUPANT		AREA			WIND. DIR. VEL. [illegible]
TOTAL AIR SUPPLY BY CO_2		LEAKAGE			[illegible]
AIR SUPPLY PER OCCUPANT BY CO_2		RATIO TO CU. CONTENT			CHECKED BY
" " " " " FAN		FLOOR AREA PER PERSON			APPROVED
AIR DISTRIBUTION %					

FIG. 12. DATA SHEET FOR SYNTHETIC AIR CHART TEST

Column D.—Odor determinations are made of the room as a whole.

The observer should go outside of the room or preferably outside of the building for a few moments previous to making the test. He then enters the room quickly, and makes his determinations of the air in the classroom by means of the olfactory sense, recording the results whether perfect, very faint, noticeable, etc., in accordance with the following table.

Freedom from Odors

100%	95%	90%	85%	80%	75%	70%
Perfect	Very Faint	Faint	Noticeable	Distinct	Decided	Strong

An Odorometer consists of a case of six vials each containing an odor substance in varying strength. It adds materially in classifying and standardizing odor perception. Its use, however, is not imperative.

Column E.—Samples of air are next taken at each station, and later analyzed for carbon dioxide, and results of this analysis plotted in *Column E* in parts in 10,000.

Column F.—Distribution of the air in the room is determined from the CO_2 analysis taken at the various stations.

The following example illustrates the method of making the calculation:

Stations	CO_2	Stations	Variations from the Average
1	11.1	1	11.1 − 10.2 = 0.9
2	9.4	2	10.2 − 9.4 = 0.8
3	10.4	3	10.4 − 10.2 = 0.2
4	9.9	4	10.2 − 9.9 = 0.3
Total	40.8	Total	2.2
Average	10.2	Average	0.55

$$\frac{0.55 \times 100}{10.2} = 5.4 = \text{per cent of variation.}$$

$$100 - 5.4 = 94.6 = \text{final per cent of distribution.}$$

After the tests have been made as described, the observer completes his test by a study of air motion and air currents. This is done by liberated puffs of ammonium chloride in different locations in the room with a suitable apparatus. Observations of the velocity and direction of travel of these small artificial smoke clouds add materially in obtaining a true conception of the velocity and general behavior of the air currents in the room.

Plotting the Test Data

The results of the tests are plotted in each column as previously described. The following data from the test illustrated on the chart on page 105 will make the entire procedure clear:

Average Dry-Bulb temp. 75 deg.—Wet Bulb temp. 59.7 deg.—Effective temp. 67.4 deg.

Effective temp. Dif. 3.4 deg.—Plot in Column *A*.
Aver. Dust Count for 4 Stations—7,000 particles per cu. ft.—Plot in Column *B*.
Aver. Bacteria for 4 Stations — 3.5 —Plot in Column *C*.
Aver. Odors Percentage — 90 per cent —Plot in Column *D*.
Aver. CO_2 — 10.2 —Plot in Column *E*.
Distribution Per Cent — 94.2 per cent —Plot in Column *F*.

Adding the penalization for these factors found at the right of each column and subtracting the sum from 100 gives a final percentage of perfect of 84.7, which is plotted in the last column.

REFERENCES

Modus Operandi of the Synthetic Air Chart, By John R. Allen (TRANSACTIONS, A. S. H. V. E., Vol. 26, 1920, p. 545).

Modern Trend in Science of Ventilation, By Perry West (JOURNAL, A. S. H. V. E., June, 1924, p. 421).

Instruments for the Measurement of Air Velocity, By J. H. Parkin (JOURNAL, A. S. H. V. E., June, 1929, p. 149).

Determining the Quantity of Dust in Air by Impingement, By F. B. Rowley and John Beal (JOURNAL, A. S. H. V. E., July, 1929, p. 233).

Determining Lines of Equal Comfort, By F. C. Houghten and C. P. Yagloglou (TRANSACTIONS, A. S. H. V. E., Vol. 29, 1923, p. 361).

Cooling Effect on Human Beings Produced by Various Air Velocities, By F. C. Houghten and C. P. Yagloglou (TRANSACTIONS, A. S. H. V. E., Vol. 30, 1924, p. 193).

Practical Application of Temperature, Humidity and Air Motion Data to Air Conditioning Problems, By F. C. Houghten, W. W. Teague, W. E. Miller (JOURNAL, A. S. H. V. E., November, 1926).

Some Physiological Reactions to High Temperatures and Humidities, By W. J. McConnell and F. C. Houghten (TRANSACTIONS, A. S. H. V. E., Vol. 29, 1923, p. 122).

Air Motion, High Temperatures and Various Humidities-Reactions on Human Beings, By W. J. McConnell, F. C. Houghten (TRANSACTIONS, Vol. 30, 1924, p. 167).

Heat and Moisture Loss from the Human Body and Its Relation to Air Conditioning Problems, By F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant (TRANSACTIONS, A. S. H. V. E., 1929, when published).

Low Humidity Psychrometric Charts, By M. C. W. Tomlinson (JOURNAL, A. S. H. V. E., February, 1929).

CHAPTER 4

SYSTEMS OF VENTILATION

Natural, Gravity and Mechanical Systems of Ventilation; Distribution of Ventilation; Design of Ventilating Systems; Equipment for Attaining Synthetic Air Chart Percentage.

VENTILATING systems roughly may be classified as natural, gravity and mechanical systems, although frequently various combinations of these systems are used. Each type has certain favorable qualities and may be especially adapted to particular kinds of buildings.

NATURAL VENTILATING SYSTEMS

Natural ventilating systems are those which utilize the wind and the temperature difference between the inside and outside air of a building to displace the air. These two forces may either cooperate or oppose each other at any given ventilating opening. If possible, therefore, openings should be arranged so that the two forces always act cooperatively, or the control should be such that only groups of openings at which cooperative action occurs will be in use. Such openings may be doors or windows for inlets and outlets, or openings in the roof to permit egress of heated air.

These systems are not nearly as amenable to control as are ventilating systems which are provided with ducts and which use heat or mechanical force to compel the movement of air.

Natural ventilation is perhaps applied most frequently to factory and industrial buildings and the openings commonly consist of windows in side walls or monitors. These openings usually provide for a large air flow, even with wind forces of slight intensity.

Natural ventilation is used in many schools, especially in the smaller sized buildings. It is used on most railway coaches and street cars, where advantage is taken of the air movement due to car motion. Where natural ventilation is used in buildings designed for human occupancy some intelligent means of heating the incoming air and of *controlling* the ventilation always must be provided.

The Wind

The wind operates to produce regions of pressure or suction about the exterior of a building as compared with the conditions that would exist in these regions if the air were still. The action of the wind is described in a paper by W. C. Randall, Airation of Industrial Buildings, A. S. H. V. E. JOURNAL, January, 1928. The principal effects of the wind when blowing directly against one face of a building are illustrated in Fig. 1. The maximum intensity of pressure at point C is approximately given by the equation.

$$P_w = 0.00048M^2 \tag{1}$$

where P_w is pressure in inches of water, and M is velocity of wind in miles per hour. The mean pressure over the windward face is somewhat less, being, perhaps, 75 per cent of the maximum.

The maximum suction occurs at point B at roof and sides, and in magnitude is about three-quarters of the maximum pressure as given by equation (1). The distance A, measuring the extent of the suction regions on sidewalls and roof, caused by the leap, or splash, of the wind from the windward face, seems to be determined by the height and width of the windward face, and is independent of the wind velocity. The intensity of the suction diminishes from the maximum at B to zero at the point where the stream lines again flow parallel to the surfaces of the building.

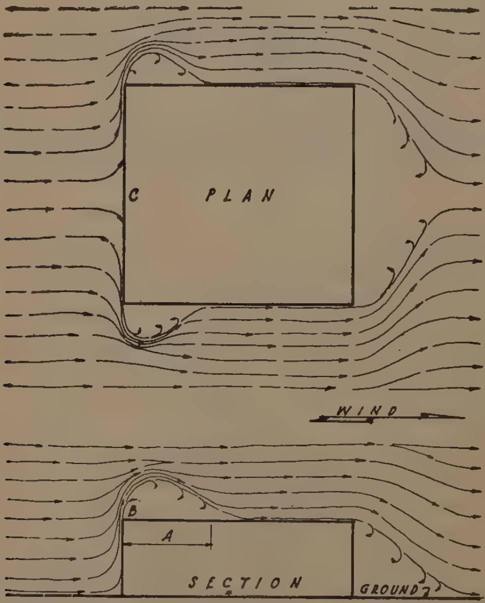


Fig. 1. The Jump of Wind from Windward Face of Building. (A—Length of Suction Area; B—Point of Maximum Intensity of Suction; C—Point of Maximum Pressure)

Maximum effect of the wind in producing ventilation can be obtained by providing openings in the windward face for ingress of air and in the leeward face, or in sidewalls and roof near the leeward face, for egress of air, in which case the air moves through the building in the same general direction as the wind; or, with no openings in the windward face, but with openings provided in the suction regions in sidewalls and roof near the windward face for egress of air, and openings in the leeward end, or in sidewalls near the leeward end for ingress of air, in which case the air movement within the building is in a direction opposite to that of the wind. A knowledge of these facts and their application will often result in a better layout of operations and processes, and even in a more favorable orientation of a building with respect to the prevailing direction of the wind, so that heat and objectionable fumes may be removed more advantageously from an industrial building.

Where the wind comes at an angle to the building, the same general rules apply. The mean pressure of the wind on the oblique faces may be considered as being approximately equivalent to the normal component of the wind, except that when the wind's direction is within 15 or 20 deg. of parallelism, the splash from the corner begins to appear, and there will then be suction near the windward corner.

Temperature Difference

Excess temperature inside a building over that outside tends to produce flow as in a chimney. The total head or force arising from this cause is given approximately by equation (2).

$$p_t = 0.000028mD \qquad (2)$$

where p_t is the total force or head in inches of water; m is the vertical distance between inlet openings below and outlet openings above; and D is the temperature difference.

The total force or head is consumed in forcing the air in at inlet openings, through the building, and out at the outlet openings. The force required to move the air through the building is usually negligible, so that the total head may be considered as being consumed at inlet and outlet openings. The part of the total head consumed in forcing the air to flow through the lower or inlet opening will be manifested as an excess of outside pressure over inside pressure at that level; while at the upper or outlet opening, the part of the total head consumed in forcing the air out will be manifested as a pressure inside, greater than outside. Thus the lower part of the building inside will be in a state of partial vacuum with respect to the outside, while the upper part will be in a state of pressure. At some point between the levels of the two openings, the pressure state is neutral, and no flow will take place through an opening at that level. This level is called the *neutral zone*. For a discussion of the neutral zone, and effect of temperature difference in general, see paper by J. E. Emswiler, The Neutral Zone in Ventilation, TRANSACTIONS, A. S. H. V. E., Vol. 32, 1926.

Relation between Head and Flow

The relation between head or pressure difference on the two sides of an opening, and the velocity that will be created thereby, is given approximately by equation (3).

$$V = 4{,}000\sqrt{p} \qquad (3)$$

where V = velocity in feet per minute through an opening, and p is the pressure difference, in inches of water, existing at that opening from any causes or combination of causes.

With V known, the flow, Q, at the opening can then be easily computed by the familiar relation.

$$Q = AVC \tag{4}$$

where Q is the flow in cubic feet per minute; A is the area in square feet, and C is a coefficient.

For openings such as result from swinging or sliding windows and doors, where the aperture is essentially an orifice, the value of C will be about 0.60.

It would be comparatively easy to calculate flow through an opening, if the pressure difference could be determined. However, so many factors participate in the general action that it is very difficult to evaluate a pressure difference arising from a given wind velocity and temperature. The difficulty is further augmented by the fact that the pressure difference is likely to have a different value for every different opening or group of openings of a building.

Although it is almost out of the question to attempt to predetermine accurately the pressure difference from fundamental data of wind velocity, wind direction, temperature difference, building dimensions and disposition of openings, in most cases merely a general knowledge of how the forces of wind and temperature difference act, what their maximum magnitudes are, and how they are disposed in and about a building, will be helpful in planning ventilation. On this basis, the following simple rules are suggested:

1. In an industrial building where furnaces, that give off heat and fumes, are to be installed, it is better to locate them in the end of the building exposed to the prevailing wind. The strong suction effect of the wind at the roof near the windward end will then cooperate with temperature difference, to provide for the most active and satisfactory removal of the heat and gas laden air.

2. In case it is impossible to locate furnaces in the windward end, that part of the building in which they are to be located should be built higher than the rest, so that the wind, in splashing therefrom will create a suction. The additional height also increases the effect of temperature difference to cooperate with the wind.

3. In the use of monitors, windows on the windward side should usually be kept closed, since, if they are open, the inflow tendency of the wind counteracts the outflow tendency of temperature difference. Openings on the leeward side of the monitor result in cooperation of wind and temperature difference.

4. In order that the force of temperature difference may operate to maximum advantage, the vertical distance between inlet and outlet openings should be as great as possible. Openings in the vicinity of the neutral zone are less effective for ventilation.

5. In order that temperature difference may produce a motive force, there must be vertical distance between openings. That is, if there are a number of openings available in a building, but all are at the same level, there will be no motive head produced by temperature difference, no matter how great that difference might be.

6. In the design of window ventilated buildings, where the direction of the wind is quite constant and dependable, the orientation of the building together with amount and grouping of ventilation opening can be readily arranged to take full advantage of the force of the wind. On the other hand, where the direction of the wind is quite variable, it may be stated as a general principle that windows should be arranged in sidewalls and monitors so that there will be approximately equal area on all sides. Thus, no matter what the wind's direction, there will always be some openings directly

exposed to the pressure force of the wind, and others opposed to a suction force, and effective movement through the building will be assured.

Control of Natural Ventilation

Control of natural ventilation depends upon hand regulation, which may be applied in two ways: *First*, by the selection of appropriate localities about the building at which to make openings, with regard to direction of the wind, and *Second*, by regulation of the amount of opening, which is accomplished by window operative devices, dampers, or louvres. Control may be effected by the regulation of either inlet or outlet openings, or both and for satisfactory results needs careful study and close attention.

Natural Ventilation Openings

The openings employed in natural ventilation are:

1. Windows (or doors) representing apertures in walls and roofs.
2. Openings in the roof which may have cowls for induced effect due to wind.

Windows have the advantage of transmitting light, as well as providing ventilating area when open. Their movable parts are arranged to open in various ways; they may open by sliding as in the ordinary double-hung, wood window; by tilting on horizontal pivots at or near the center; or by swinging on pivots at top or bottom. Whatever the form and type of window used the thing of essential importance in ventilation is the amount of clear area that can be made available. The motive head to produce flow through windows is almost entirely dependent upon the distribution of those motive forces in and about a building, as discussed under wind and temperature difference. A pivoted window, projecting out from the plane of the wall is bound to impose some obstructive influence upon such air currents as exist in that particular vicinity, and may result in the production of some localized pressure or suction that will influence flow there, and to that degree, one type of window might give more or less active ventilation than another. But, speaking generally, the motive head causing flow through a window is determined by the forces of wind and temperature difference existing there, and not by the kind of window, except in so far as the kind of window establishes the area of opening.

Windows may be arranged for individual operation, or they may be grouped in long runs, as in factory buildings. Those used in office buildings may have deflecting devices at the sills for avoiding direct draft upon occupants, or a bottom pivoted ventilator, arranged to swing in at the top, may serve the same purpose.

Roof outlets concern mechanical as well as natural ventilating systems. A roof ventilator of the unit type consists of a structure built up around a roof opening in such a way as to cause the wind to *induce* a suction in the vicinity of the opening, and so create an outflow. Since roof ventilators are intended for installation on roofs of buildings, and function as outflow openings only, they constitute but a part of a ventilating system, and attention must be given to the provision of openings for inflow. It is evident that such ventilators could not function even in the strongest wind, and with the maximum temperature difference, without inlet openings. Often such ventilators must depend upon infiltration only for inflow. Inlet openings of about twice the area of the roof ventilators should be provided where natural ventilation is used. Dampers should be installed in ventilators with adequate and accessible operating mechanism.

In considering roof ventilators, the general action of the wind upon the building, as described in the earlier part of this chapter, should be kept in mind.

A ventilator located within the region indicated by *A* in Fig. 1, will not contribute any inductive effect because in this region there is little or no wind. The ventilator opening will function, but will function in the same way as would a window in that locality, because of the resultant effect of the suction produced by the wind acting upon the building, and by whatever temperature differences prevail.

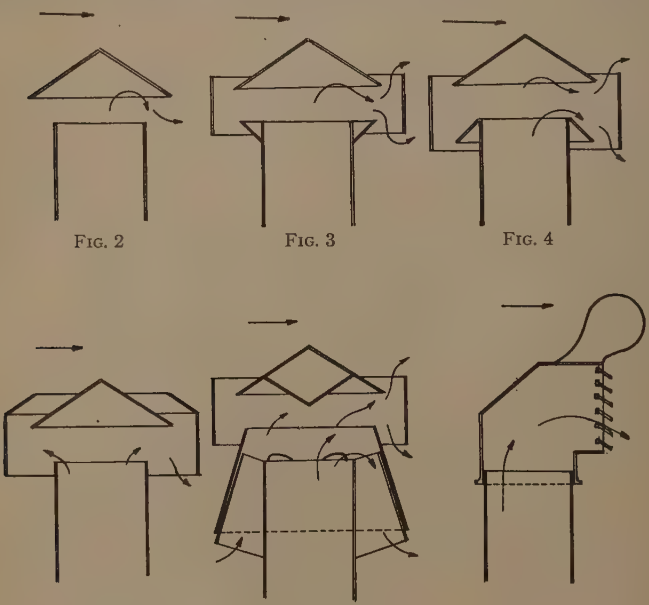


FIG. 2 FIG. 3 FIG. 4

FIG. 5 FIG. 6 FIG. 7

VARIOUS STYLES OF ROOF VENTILATORS

Circular roof ventilators are effective if placed in the wind-flow, no matter what the direction of the wind. On the other hand, if ventilators do not stand in the path of the wind, and depend only upon the same forces for producing flow as do windows or any other plain opening, they are at a disadvantage because of the greater resistance of their more complex passages.

Location of Discharge Openings

The discharge openings for all systems of ventilation must be arranged so that they shall not be influenced by wind or other atmospheric conditions.

If a ventilating outlet looks out horizontally through the side wall of a building, sooner or later a pressure from outside will oppose the air flow and the occupants of the building will suffer.

Even when the outlets for ventilation are well above the roof, they must be as distant as possible from higher buildings or obstructions, since the jumps and the eddies illustrated in Fig. 1 are ever-present to the leeward and may cause difficulty.

Types of Roof Ventilators

The simplest form of unit ventilator is the *stationary* type shown in Fig. 2 and consists of an outlet pipe with a conical hood above it. The addition of a storm band, as shown in Figs. 3, 4, and 5, gives an increased protection against the entrance of rain or snow. The storm band, if placed so close to the cones as to restrict the outflow of air, interferes with ventilation. On the other hand, if the openings are made large enough to permit free egress of the inside air, the storm band increases the ventilation by better utilizing the wind velocity to produce suction.

A further development of the latter principle is the *siphon* ventilator, as illustrated in Fig. 6, in which siphons or ducts are introduced for the particular purpose of producing suction.

In the swiveling or *rotary* ventilators, typified by Figs. 7 and 8, a freely rotating cowl is used. A wind vane is provided for keeping the opening facing away from the direction of the wind. This type allows free egress of the inside air (unless the outlet is made unduly small). Its action depends chiefly upon the suction produced by the wind on the leeward side of the ventilator.

In the *induction* or *ejector* type of ventilator, which is also of the swiveling or rotary type, Fig. 9, the kinetic energy of the wind is intended to create a suction inside the cowl as well as outside.

Resistance to flow of air in the ventilator is caused by: (1) restricted outlet openings, or (2) many turns or changes of the direction of the air flow. As regards the first item, this depends entirely upon the proportions, and not upon the type; some of the stationary ventilators have smaller, and others have larger outlet area than some cowl ventilators of the same nominal size. Regarding the second item, the swiveling cowl ventilators offer less resistance than the stationary type, in that the direction of air flow is changed as little as possible.

Unless swiveling ventilators move very freely, the opening, at times, faces towards the wind so that ventilation produced by temperature difference is much reduced, or wholly counteracted. In that case, snow and rain may blow in. The rumbling or creaking noise caused by a hard turning swivel ventilator is also very unpleasant. These troubles are, of course, eliminated in well-designed ventilators, but must be kept in mind.

In Fig. 10 is shown a rotary or *air-turbine* ventilator, which rotates continuously under the action of the wind, the motion being produced by the difference of wind pressure on the convex and concave sides of the vanes. This type of ventilator must be very carefully designed if it is to be leak-proof, and if the noises and impact forces, due to ice accumulating on the vanes in the winter are to be eliminated.

The *continuous type of roof ventilator* is illustrated in Fig. 11. It furnishes a continuous opening in the roof throughout the length of the building, and is in effect a ridge louvre or monitor. It is stated that the high temperature of the air immediately beneath the sheathing, resulting from exposure of the roof to the sun's rays, induces a powerful convective effect along the pitched roof toward the opening which offers a direct avenue of escape, whereas in the unit type of ventilator, the free egress of the air is confined to definite points along the roof, and the natural upward flow is diverted with some loss, to a longitudinal movement. These ventilators are expected to function by the force of temperature difference alone, and have no external features designed to generate a suction by the action of the wind. The absence of a conspicuous external structure makes this type of ventilator particularly suitable for certain types of buildings.

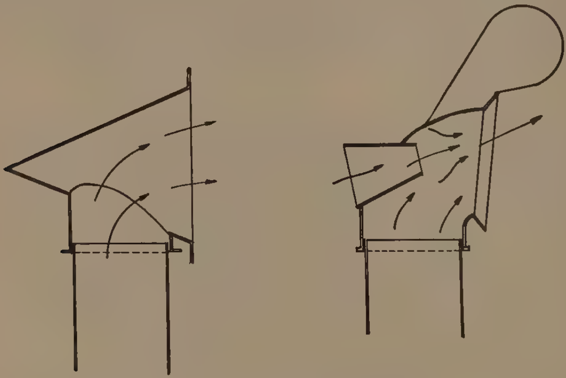


FIG. 8 FIG. 9

ROTARY VENTILATORS

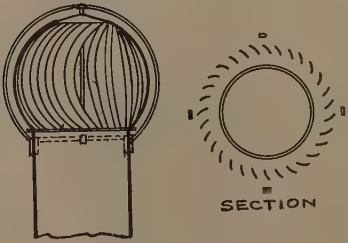


FIG. 10

AIR-TURBINE VENTILATOR

Selection of Roof Ventilators

While the average efficiency of one class of roof ventilators will be higher or lower than the average efficiency of another class, this does not in any way determine the capacity of individual ventilators, as ventilators of the same class and, which from a casual observation appear to be the same, may have entirely different characteristics, due to the fact that some of the fundamentals have been overlooked or changed in one or the other.

The principles which should be followed in the selection of roof ventilators are:

A—Stationary Ventilators.

1. A head sufficiently large to produce a large low-pressure area on the side opposite the wind, and to give an area of outlet for the air leaving the head large enough to obviate undue resistance to flow. At the same time the head should not be so large as to be unwieldy in handling or to be structurally weak when erected.

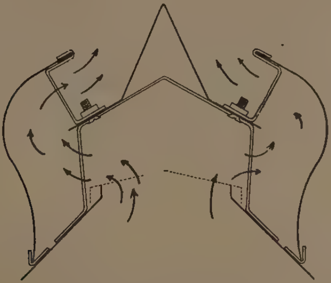


FIG. 11. CONTINUOUS TYPE ROOF VENTILATOR

2. A storm band on stationary non-siphoning ventilators should be sufficiently wide and so placed as to prevent the entrance of external air into the ventilator head.
3. If the ventilator is a siphoning type, additional outlet air space must be provided in the head in order not to restrict the air passage from the exhaust pipe.

B—Rotary Ventilators.

1. A flaring outlet from a rotary ventilator will give a better exhaust than a straight outlet.
2. Practically frictionless and noiseless turning of the ventilator head, when the wind direction changes. The head should turn at very low wind velocities.
3. Smallest possible change of direction of the air ascending from the building and least possible resistance to its egress by louvres or other obstructions at the outlet opening.

C—All Ventilators.

1. Freest possible outlet for the air from the building, with large areas and smallest possible change of direction of the air flow.
2. Freedom from down drafts and from entrance of rain or snow.
3. Freedom from being rendered inoperative by collection of snow or formation of ice on ventilator.

Capacities of Unit Type Roof Ventilators

The variety of factors affecting capacity makes it essential for the user of ventilators to exercise great care in respect to the item of capacity. All comparisons of capacity must be referred to a given dimension, namely the throat area, corresponding to the nominal size of the ventilator.

Careful tests of ventilators of various types have been made by reliable investigators, and the reader is referred to their work for information on capacities (See TRANSACTIONS, A. S. H. V. E., Vol. 27, 1921, p. 67; Vol. 28, 1922, p. 189; and Vol. 29, 1923, p. 39. Also Bulletin No. 14, Engineering Experiment Station, Kansas State Agricultural College).

Conservative figures for the best types of ventilators now on the market, under conditions of unrestricted flow of air to the ventilator, are given by the equation:

$$Q = A \times \left[\frac{36 \times \sqrt{H \times (t_i - t_o)}}{6 + V} + 20 \times V \right].$$

where

Q = cubic feet of air exhausted per hour through a ventilator having a free area at the throat of A square inches, mounted on a roof at a height of H feet from the center of the ventilator outlet to the inlet opening of the building, and with a wind velocity of V miles per hour, and average temperature t_i inside t_o outside.

High class ventilators, for instance those of the ejector type, will, under favorable conditions, discharge continuously 25 per cent more air than these conservative figures indicate. Capacities are lower, on the other hand, if ventilators of lower efficiency are used, or if the flow of air into or through the building is restricted, or if the ventilator is not exposed to the free sweep of the wind. Tests occasionally show considerably higher discharge rates over short periods of time. These abnormally high results are produced by the action of the wind upon certain openings of the building; they are not due to the ventilator itself, and cannot be depended upon for continuous ventilation if the direction of the wind changes. In the smaller sizes of ventilators (12 in. or less in throat diameter) the air discharge per square inch of cross-sectional area is reduced, on account of the frictional resistance and, in the rotary types, on account of reduction of free area by the supports, bearings, etc.

Example.—What is the capacity of an 18-in. ventilator, located 35 ft. above the inlet openings, with 6 miles per hour wind velocity, 50 deg. fahr. outside temperature, 68 deg. fahr. inside temperature?

Answer.—$A = 0.7854 \times (18)^2 = 255$ sq. in.

$$Q = 255 \times \left[\frac{36 \times \sqrt{35 \times \left(68 - 50\right)}}{6 + 6} + 20 \times 6\right] = 50{,}000 \text{ cu. ft. per hour,}$$

average capacity under these conditions.

The air supply per person and per hour is given in Chapter 3, and the number of the renewals of air contents per hour is given in Chapter 2.

To obtain effective, uniform ventilation and avoid local drafts, the ventilators should not be placed more than 30 ft. apart; 20 ft. apart is a good average. It is best, although not absolutely necessary, to locate the ventilator at the ridge of the roof, unless the building exceeds 40 ft. in width, in which case two rows of smaller ventilators should be used. Where the building to be ventilated is surrounded by higher buildings which obstruct air currents, it is desirable to extend the ventilators above the buildings by mounting them on stacks.

Example.—A foundry building is 40 ft. wide, 200 ft. long, with an average height of 40 ft.; the ventilators are to be mounted at the ridge of the roof, at a height of 55 ft. above the floor. What number and size of ventilators are required?

Answer.—In this case, ventilation is especially necessary in summer. The air in the building should not be over 10 deg. fahr. warmer than the outside air. The wind velocity may be as low as 4 miles per hour. Spacing the ventilators, tentatively, 25 ft. apart, 8 ventilators would be required. Under average conditions, 10 air renewals per hour are sufficient. If the foundry is small and cramped, and pouring takes place over a large section of the floor space, 15 or more air renewals per hour may be needed. On the basis of 10 renewals per hour, the capacity of each ventilator must be:

$$Q = \frac{10 \times (200 \text{ ft.} \times 40 \text{ ft.} \times 40 \text{ ft.})}{8} = 400{,}000 \text{ cu. ft. per hour}$$

The discharge per square inch of throat area under these conditions is;

$$\left[\frac{36 \times \sqrt{55 \times 10 \text{ deg.}}}{6 + 4 \text{ mi. per hr.}} + 20 \times 4 \text{ mi. per hr.}\right] = 165 \text{ cu. ft. of air per hour.}$$

The required throat area per ventilator is

$$\frac{400{,}000}{165} = 2420 \text{ sq. in.}$$

if there is no resistance and no wind pressure.

The diameter is $\sqrt{\frac{2420}{0.7854}} = 55.5$ in. Standard sizes are 54 in. and 60 in. Either eight—54-in. or else seven—60-in. ventilators could be used, spaced respectively 25 ft. or 28 ft. apart.

The foregoing is based on the use of high class ventilators. If ventilators of lower efficiency are used, or if the air flow into the building is restricted (as in winter) larger ventilators may be required.

GRAVITY VENTILATING SYSTEMS

Gravity ventilating systems are those which use openings especially provided for air flow, with ducts and flues, and which depend on the difference in weight caused by heat to compel the movement of air.

Gravity systems obtain the necessary pressure difference by using chimneys which are called vent flues, and which become more and more effective as the difference between the outside and inside temperatures increases. As long as a temperature difference of not less than 40 deg. between indoors and outdoors exists, these systems can be depended upon for a definite result. With slight temperature differences, the effectiveness of gravity systems decreases rapidly.

Gravity ventilating systems must usually operate, except when the rooms are on the windward side of the building, at somewhat lower atmospheric pressure than that out-of-doors. This is due to the necessity for pressure-difference to cause air to enter the rooms on the leeward side.

Ejector type ventilators and inlet hoods will cause very effective movement of air *while the wind blows*, proportional to the wind velocity, but the results are not always dependable since they are so very profoundly affected by wind movement.

Direct-Indirect Gravity Ventilating Systems

Direct-indirect gravity ventilating systems have small openings through the outside walls below windows, with encasement of the superimposed radiator sections and are sometimes used in school building gravity ventilation. This system is very difficult to control, and becomes less and less effective as the temperature difference between indoors and outdoors decreases. The windward rooms may receive more air supply than can be warmed, while simultaneously, the leeward rooms are losing heated air due to reverse air currents through the direct-indirect heaters, due to the low pressure zone which always occurs in the lee of any obstruction during a high wind.

Indirect Systems of Gravity Ventilation

Indirect systems of gravity ventilation with convectors in the basement may operate satisfactorily so long as their air supply comes from windward and the temperature conditions inside and out permit the convectors or radiators to be heated. As soon as the heat is shut off from these convectors and the ducts become equalized as to temperature, air movement ceases.

For the first hour or so of school on a cold morning, a well-designed gravity ventilating system will function well. After that period and in comparatively mild weather, gravity ventilating systems cease to function since heat must be shut off from the radiator and the temperature difference which causes air movement must, without heat, decrease rapidly.

Gravity ventilating systems are not well adapted to the installation of humidifiers and air cleaners, and their control and upkeep with such systems is difficult.

Studies of buildings which operate with gravity ventilating systems indicate that the windward rooms usually may, with care, be provided with satisfactory air movement and temperature control, but that during this time the leeward rooms get too warm and usually cannot be made to receive any air supply except that which comes through the windward rooms and the corridors.

MECHANICAL VENTILATING SYSTEMS

With mechanical systems of ventilation the circulation of air is maintained positively and uniformly regardless of outside air conditions and when properly designed and operated, mechanical systems will furnish any desired temperature or humidity, under automatic control.

In all situations where controlled ventilation is desired, mechanical ventilation is necessary. In all situations where temperature control and freedom from odors or dangerous gases or dust is required, mechanical ventilation is necessary. In all situations where air cooler than that in the rooms must be handled, as with dehumidifying and cooling systems, mechanical ventilation is necessary.

Central Supply Systems

Central supply systems of mechanical ventilation may operate independently, or in conjunction with the heating of the building. In some cities, for instance, the schools for many years have been heated and ventilated satisfactorily with *combined* heating and ventilating, no heaters being placed in the classrooms. Temperature is controlled by the automatic varying in proportions of the cool air and of the warm air. The heating, ventilation and cooling of many large banks and theaters is accomplished with combined heating and ventilating systems.

With this system it is necessary to operate the fans in order to warm the building and to control the conditions. There are obvious advantages in such an arrangement for certain buildings. It tends to insure proper maintenance and intelligent operation.

When the heating is accomplished with radiators, heat conductors or local heaters, separate from the ventilation, the scheme is called a *split* system. This type of mechanical ventilation is used for many schools. With the split system the building can be heated and conditions can be controlled to some extent even though the fans are shut down. This arrangement is advantageous for after-hours occupancy, and also for freedom from danger of shut-down in case the power for fan operation fails, etc.

The outstanding advantage of central supply systems of mechanical ventilation is that they are especially adapted to control of the air temperature and moisture and cleanliness.

Unit Supply Systems

Unit supply systems of mechanical ventilation also may operate to warm the air sufficiently to care for the heating of the building, or may be accompanied by independent heating apparatus.. Each unit has a fan and an electric motor and a heater, and each unit should have a thermostat which insures positive control of the temperature of the air delivered. It is possible to provide viscous dust filters with unit ventilating machines, but the cleaning and maintenance of such filters in the constricted areas which exist in many unit ventilating machines is an arduous and often neglected task. Unit ventilating machines in somewhat larger sizes than the conventional schoolroom types are available with built-in humidifying arrangements, including water tanks, pumps, eliminators and automatic humidity control. They may easily be connected with central water-cooling equipment located remotely, and so may be used for dehumidifying and for air cooling. (See Chapter 9).

Direct fired unit systems of ventilation are used in industrial work, comprising warm-air furnaces with fans and motors.

All supply systems of ventilation may take air from out-of-doors, or may recirculate all or a portion of the air. Any of them may operate in connection with gravity outlets or in connection with mechanically induced outlets. For the purposes of this chapter, mechanically induced exhaust ventilation will be called exhaust ventilation.

Exhaust Systems

Exhaust systems of mechanical ventilation may be used in connection with any system of air supply. They will always be more effective if used to supplement controlled equipment for replacing with new air the exhausted air and its objectionable tenantry of gas or dust. Great skill may be used to advantage in the design of exhaust systems, and co-operation is required in most cases by the designer of the building itself. For instance, if an exhaust ventilating system is installed in a hotel kitchen which has many windows on three outside exposures, the inevitable opening of these windows by employees, plus the effect of wind pressure, will make the successful operation of such a system very difficult.

The outlets from the building for discharged air from exhaust systems of ventilation must be given careful attention. No dependence can be placed upon outlets which look out horizontally even though they come from powerful fans, as previously stated. A cold gale of wind against such an outlet can stop the egress of the objectionable gases. The exhaust fan outlet should look up and it must be far enough away from the windows of higher buildings and from the air supply inlets to ventilating systems that no cross-contamination may occur.

DISTRIBUTION OF VENTILATION

Distribution of the air used for ventilation to remove the aerial envelope of the bodies of the people is probably the most important function of a satisfactory ventilating system. There is no particular rule for locating inlets or outlets which can be laid down without also stating exceptions to the rule. The effectiveness of the distribution of air supply or exhaust is influenced profoundly by the temperatures of the walls and glass, and the heaters, lights and bodies of the people who occupy the room.

Inlets and Outlets in Schoolrooms

A very successful experimental school classroom ventilating scheme used a 3-in. diameter inlet under the book-shelf in each desk. Other favorable and satisfactory inlet locations, are:

1. Slots in the floor under radiators.
2. Grilles looking down through the ceiling.
3. Grilles looking up in the window stools.
4. Grilles looking up, as with schoolroom unit ventilating machines.
5. Horizontally discharging diffusers on the side of the room looking toward the windows.

It is reasonably safe to suggest that with the fifth type of inlet, several openings, symmetrically located, are better than a single unsymmetrical opening. Outlets from schoolrooms usually are on the sides of the rooms opposite the major glass exposure or are in the inner ends of the cloakrooms when the cloakrooms do not have any doors to separate them from the classrooms. Schoolroom ventilation exhaust openings are close to the floor.

Inlets and Outlets for Theaters, Auditoriums, Etc.

Successful plants are in operation using the upward system of air circulation from hooded openings in the floor under each seat, but there is less complaint and probably less danger of trouble from drafts in most auditoriums if the downward system of air circulation is used. Unless the ceiling of the room is very lofty, however, the downward-going air must be diverted and baffled horizontally so as to mix with the air already collected in the neighborhood of the inlet, or there will be complaint of drafts whenever air even slightly cooler than that already in the room is admitted. With comparatively low ceilings it is possible to use very satisfactorily these inverted diffusers with their somewhat high-speed horizontally-discharging air currents.

Inlets and Outlets for Industrial Service

In many cases it is desirable to use high velocity outlets from supply ducts, arranged so that they act like inspirators, the jets tending to draw large volumes of the surrounding, otherwise stagnant, air along with them.

In other cases drop-pipes from overhead ducts may have chain-suspended baffle plates across the bottom which may be adjusted to divert the major part of the air in any desired direction at any desired velocity.

Inlets and Outlets in General

When there is no heat loss from the room being ventilated, the entering air for ventilating purposes may be at very nearly the same temperature as the air in the room, and the air may be moved across the room, and the inlets and outlets may be opposite each other. They may be successful if calling for air circulation from floor to ceiling, or from ceiling to floor.

When, however, windows and cold walls and radiators must interpose their disturbing influence, or when there are gases or fumes or excess heat in great quantities, or when the entering air is cooler than the air in the room, complications are bound to occur, and in general the cooled air in the room or the cool entering air will fall to the floor, while the lighter heated air will rise to the ceiling. Therefore, in many cases both inlets and outlets, well designed, may be placed at the ceiling, the entering cool air being diffused and warmed somewhat as it falls slowly toward the floor, while the overheated air is skimmed off the top.

DESIGNING THE VENTILATING SYSTEM

After the heating and ventilation requirements have been calculated, the size of the heater and fan may be calculated for a given friction, temperature range, pressure loss in ducts, etc. Pressure losses build up rapidly as velocities are increased and generally they vary approximately as the square of the velocity. The allowable pressure loss through the heater should in general not exceed 50 per cent of the total static pressure of the system. In public building practice the allowable pressure loss through tempering coils and reheaters should be under 0.5 in. of water and when an air cleaner is used the friction through the tempering coil and reheater should not exceed 40 per cent of the total resistance, as a rule.

For data on the design and construction of duct systems for ventilating work, see Chapter 27.

A greater friction allowance for the heaters than 50 per cent of the total may be made in industrial work where the duct runs are comparatively short and where the resistance of the heater is a large part of the entire pressure loss in the system.

The fan may be selected when the following facts are known:

1. Quantity of air required in cubic feet per minute.
2. Static pressure of the system (ducts, heaters, air cleaners, entrance connections, etc.)

The rating used for the fan should have been determined by the A. S. H. V. E. Standard Code for Testing Centrifugal and Disc Fans (See TRANSACTIONS, 1923, Vol. 29, p. 407 and Chapter 26).

A mechanical ventilation installation rightly designed and operated will be quiet and efficient, but every precaution should be taken to prevent vibration or sound transmission to the rooms.

It is usually more effective to float both fan and motor on a base common to both on cork, including its foundations, than to attempt to isolate each separate apparatus. There are several systems for soundproofing of machinery available and contracts may be made covering assured results.

EQUIPMENT FOR ATTAINING SYNTHETIC AIR CHART PERCENTAGES

The following classifications are given to assist in selecting the type of equipment necessary to attain certain percentages on the Synthetic Air Chart described in Chapter 3. It will be understood that considerable variation may be found in certain classes of equipment due to individual ideas on the part of the designer, the character of the workmanship, the location of the building in which the equipment is installed, etc.; nevertheless, if the equipment is properly designed, installed and operated, it will give at least the percentage listed under any particular classification. To design an installation approaching 100 per cent, it is necessary to provide apparatus for heating and humidifying the air, and for cleaning it and distributing it with controlling devices that will maintain the temperature and humidity in conformity with the comfort lines as given by the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS. Any equipment omitted or any part that is ineffective will reduce the final percentage attained.

Class "A" equipment capable of attaining over 95 per cent on the

Synthetic Air Chart, consisting of a mechanical system including the following apparatus:

1. Mechanical air supply having a maximum capacity of 30 cu. ft. per minute per occupant.
2. Mechanical exhaust equipment.
3. Excellent air distribution.
4. Accurate automatic temperature control.
5. Efficient humidifying apparatus.
6. Accurate automatic humidity control devices.
7. Efficient air cleaning apparatus.

Note.—It is understood that 100 per cent efficiency is a physical impossibility since this would mean 100 per cent efficiency in the air cleaning device, in air distribution, in temperature control, etc. Perfect results of this kind have not yet been obtained in practice, although it is possible to obtain approximately 99 per cent of the Synthetic Air Chart with an apparatus of this kind carefully designed and installed and skillfully operated.

Class "B" equipment capable of attaining from 90 to 95 per cent on the Synthetic Air Chart, consisting of a mechanical system including the following apparatus:

1. Mechanical air supply having a maximum capacity of 30 cu. ft. per minute per occupant.
2. A well designed gravity exhaust system.
3. Efficient air distribution by properly located supply and exhaust openings.
4. Automatic temperature control.
5. Adequate humidifying apparatus.
6. Automatic humidity control.

Note.—All cleaning devices have been omitted from Class "B" as 95 per cent can be obtained under ordinary conditions without air cleaning. In exceptionally clean localities higher percentages will result. Where the air contains considerably more than the average amount of dust slightly lower percentages may result. Air cleaning apparatus may be substituted in Class "B" for automatic humidity control without materially affecting the final percentage.

Class "C" equipment capable of attaining from 85 to 90 per cent on the Synthetic Air Chart, consisting of a mechanical system including the following apparatus:

1. Mechanical air supply having a maximum capacity of 30 cu. ft. per minute per occupant.
2. Gravity exhaust.
3. Efficient air distribution by properly located supply and exhaust openings.
4. Automatic temperature control.
5. Adequate humidifying apparatus.
6. Humidity control from one or more selected points or manual control.

Class "D" equipment capable of attaining 80 to 85 per cent on the Synthetic Air Chart, consisting of a mechanical system including the following apparatus:

1. Mechanical supply having a maximum capacity of 30 cu. ft. per minute per occupant.
2. Gravity exhaust.
3. Good air distribution.
4. Automatic temperature control from one or more selected points or manual control.

Class "E" equipment capable of attaining from 75 to 80 per cent on the Synthetic Air Chart.

1. Mechanical air supply with gravity exhaust but without air cleaning device, humidifying apparatus, temperature or humidity control.
2. Direct-indirect systems with either mechanical or gravity exhaust.
3. Open window and other so-called natural systems of ventilation.

The recommended percentages of ventilation perfection based on the Synthetic Air Chart, for various types of buildings are given in Table 1.

TABLE 1. RECOMMENDED PERCENTAGES OF VENTILATION PERFECTION BASED ON THE SYNTHETIC AIR CHART

TYPE OF BUILDING	PART OF BUILDING	RECOMMENDED PERCENTAGE
SCHOOLS	Class Rooms	92
	Normal Training Rooms	90
	Domestic Science Rooms	90
	Auditoriums	90
	Corridors	85
CHURCHES		85
HOSPITALS	Wards	90
	Operating Rooms	95
	Other Rooms	90
THEATERS	Auditoriums	85
	Dressing Rooms	85
DANCE, LODGE AND ASSEMBLY HALLS		85
OFFICE BUILDINGS	Offices in buildings where persons are continuously employed	90
DEPARTMENT STORES		88
OTHER STORES		88
INDUSTRIAL BUILDINGS	The percentage desirable for industrial buildings will vary over a considerable range, depending upon the character of the work and the processes employed, modified to a considerable degree by the dust content of the air and the possibility of maintaining it free from objectionable dust and fumes. This requires careful study for each installation.	

CHAPTER 5

HEATING WITH WARM AIR FURNACES BY GRAVITY

Data on Furnaces; Leader Sizes; Stack Sizes; Air Temperatures; Register Sizes and Locations; Recirculation; Layouts; Standard Installation Code.

THERE are several typical systems of warm-air heating in common use today. An analysis of the systems mentioned in the following list will show that warm air may be employed as the heating medium in almost all types of heating requirements: (1) Gravity warm-air furnace systems, with or without booster fans for forced circulation and combination air and water systems for isolated rooms; (2) Fan furnace heating systems (see Chapter 6); (3) Fan-coil and unit heating systems (see Chapter 9); (4) Indirect radiating systems (see Chapter 16).

Each system has its particular application: No. 1 is intended particularly for residences and small structures; No. 2 for large residences, small theatres, churches, schools and stores; No. 3 for large buildings, theatres, schools, churches and factories; No. 4 for homes, hotels, schools, etc.

In this chapter of THE GUIDE, consideration will be given to the design of gravity circulating warm-air heating systems. For fan circulating systems see Chapters 4, 6, 7, 9, and 27. Complete engineering data, including the procedure to be followed in designing a typical system, are presented in the first part of this chapter, while the last part of the chapter presents a Standard Code Regulating the Installation of Gravity Warm Air Heating Systems in Residences, approved by the *National Warm Air Heating Association*, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *National Association Sheet Metal Contractors*, as a workable Code for furnace men.

DEFINITIONS

In general, warm-air furnace heating plants consist of a fuel-burning furnace or heater enclosed in a casing of sheet metal or brick, which is placed in the basement of the building. The heated air, taken from the top or sides near the top of the furnace casing, is distributed to the various rooms of the building through sheet-metal warm-air pipes. The warm-air pipes in the basement are known as leaders, and the vertical warm-air pipes which are run in the inside partitions of the building are

---

All figures and much of the engineering data which follow are from Bulletin No. 141, Warm Air Furnace and Heating Systems, Part II, by Professors A. C. Willard and A. P. Kratz, Engineering Experime Station, University of Illinois.

called stacks. The heated air is finally discharged into the rooms through registers which are set in register boxes placed either in the floor or in the side wall, usually at or near the baseboard.

The air supply to the furnace may be taken (1) entirely from inside the building through one or more recirculating ducts; (2) entirely from outside the building, in which case no air is recirculated, or (3) through a combination of the inside and the outside air supply systems.

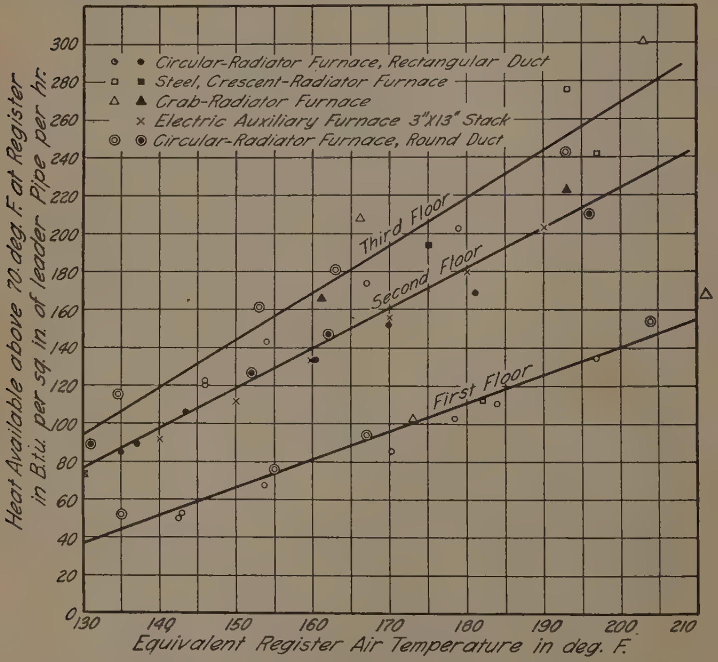


FIG. 1. VALUE OF SQUARE INCH OF LEADER PIPE AREA FOR FIRST, SECOND, AND THIRD FLOORS

Furnace heating plants may be: (1) of the gravity circulating type in which the motive-head-producing flow depends upon the difference in weight between the heated air leaving the casing and pipes and the cooler air entering the bottom of the casing, or (2) of the fan circulating type in which a fan may supply all or part of the motive-head producing flow. In most house installations, the former type of system is in general use.

EIGHT DESIGN RULES

The design of a furnace heating system involves the determination the following items:

a. Heat loss in B.t.u. from each room in the building.

b. Area and diameter in inches of warm-air pipes in basement (known as leaders).

c. Area and dimensions in inches of vertical pipes (known as wall stacks).

d. Free and gross area and dimensions in inches of warm-air registers.

e. Area and dimensions of (1) recirculating or (2) outside air supply ducts in inches. There may be one or more of each of these.

f. Free and gross area and dimensions in inches of recirculating registers.

g. Size of furnace necessary to supply the warm air required to overcome the heat loss from the building. This "size" should include square inches of leader pipe area which furnace must supply. It is also desirable to call for a minimum bottom fire-pot diameter in inches, which is the nominal grate diameter.

h. Area and dimensions in inches of chimney lining and smoke pipe. If an unlined chimney is to be used, that fact should be made clear.

CALCULATING HEAT LOSSES

The heat which will be required for each room in the building depends on (1) the heat transmission losses through walls and glass as well as through floors and ceilings when the latter two are next to unheated spaces, and (2) the infiltration of cold air through the cracks around outside windows and doors. Calculations for the heat required in B.t.u. per hour should be made as indicated in Chapter 2, Heat Losses from Buildings.

LEADER PIPE SIZES

In a gravity circulating warm-air furnace system the size of the leader to a given room depends on the temperature of the warm air entering the room at the register. A reasonable air temperature at the registers must, therefore, be agreed upon before the system can be designed. The *National Warm Air Heating Association* has approved an air temperature of 175 deg. fahr. at the registers as satisfactory. At this temperature, the heat-carrying capacity (heat available above 70 deg. fahr.) per square inch of leader pipe per hour for first, second or third floors is shown by Fig. 1 at 175 deg. fahr. to be 105, 170 and 208 B.t.u. respectively. For average calculations, the values 111, 166 and 200 will simplify the work and may be satisfactorily substituted for these heat-carrying capacities. If H represents the total heat to be supplied any room, the resulting equations are:

$$\text{Leader areas for first floor, square inches} = \frac{H}{111} = \text{approximately } 0.009H \qquad (1)$$

$$\text{Leader areas for second floor, square inches} = \frac{H}{166} = \text{approximately } 0.006H \qquad (2)$$

$$\text{Leader areas for third floor, square inches} = \frac{H}{200} = \text{approximately } 0.005H \qquad (3)$$

In designing for a lower warm-air register temperature, say 160 deg fahr., the factors 111, 166 and 200 become 80, 140 and 166 (Fig. 1 160 deg. fahr.), and the resulting equations are:

$$\text{Leader areas for first floor, square inches} = \frac{H}{80} = \text{approximately } 0.012H \qquad (4)$$

$$\text{Leader areas for second floor, square inches} = \frac{H}{140} = \text{approximately } 0.007H \qquad (5)$$

$$\text{Leader areas for third floor, square inches} = \frac{H}{166} = \text{approximately } 0.006H \qquad (6)$$

These equations are applicable to straight leaders from 6 to 8 ft. in length. Longer leaders must be very thoroughly covered or else the vertical stacks must be increased in area as discussed under wall stacks. If some provision is not made for these longer leaders, the air temperature may be much lower than anticipated and the room will not be properly heated.

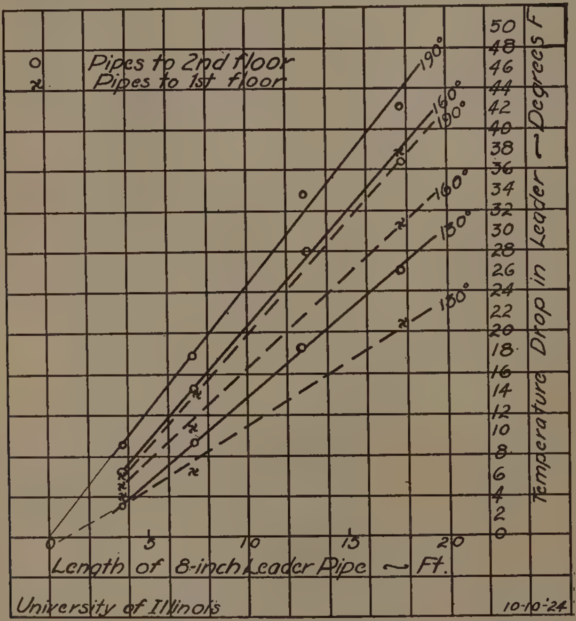


FIG. 2. LOSS IN TEMPERATURE IN 8-IN. LEADER PIPE OF VARIOUS LENGTHS AT DIFFERENT REGISTER TEMPERATURES

While Fig. 1 takes care of the drop in temperature in straight leaders up to 8 ft. in length connected to stacks having about 75 per cent the area of the leader, the designer must make allowances for all other conditions. The temperature drop in leaders of various lengths at three ifferent register temperatures is shown in Fig. 2.

Leader sizes should in general be not less than obtained by equations

(1) to (3) nor should leaders less than 8 in. in diameter be used. It is not considered good commercial practice to specify diameters except in whole inches, although there is no real reason for not using half inches if necessary. The tops of leaders should be at the same elevation as they leave the furnace bonnet, and from this point there should be a uniform up-grade of 1 in. per foot of run in all cases. Leaders over 12 ft. in length are to be avoided or should receive very special attention.

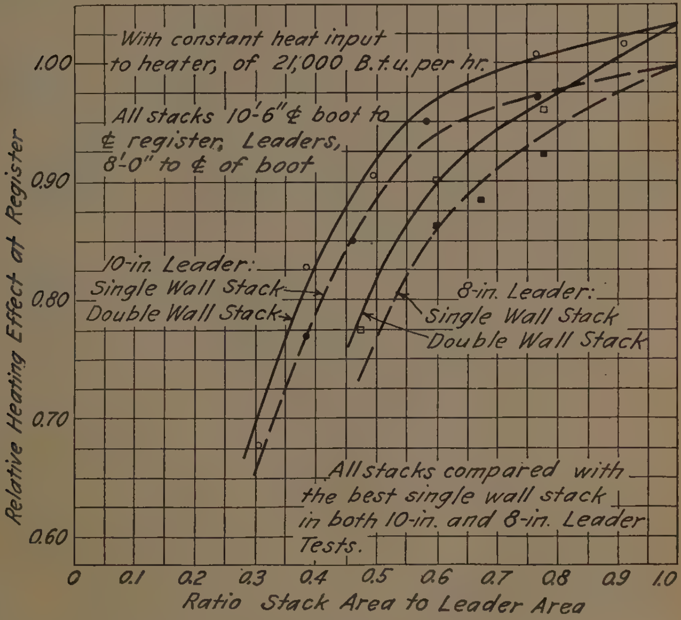
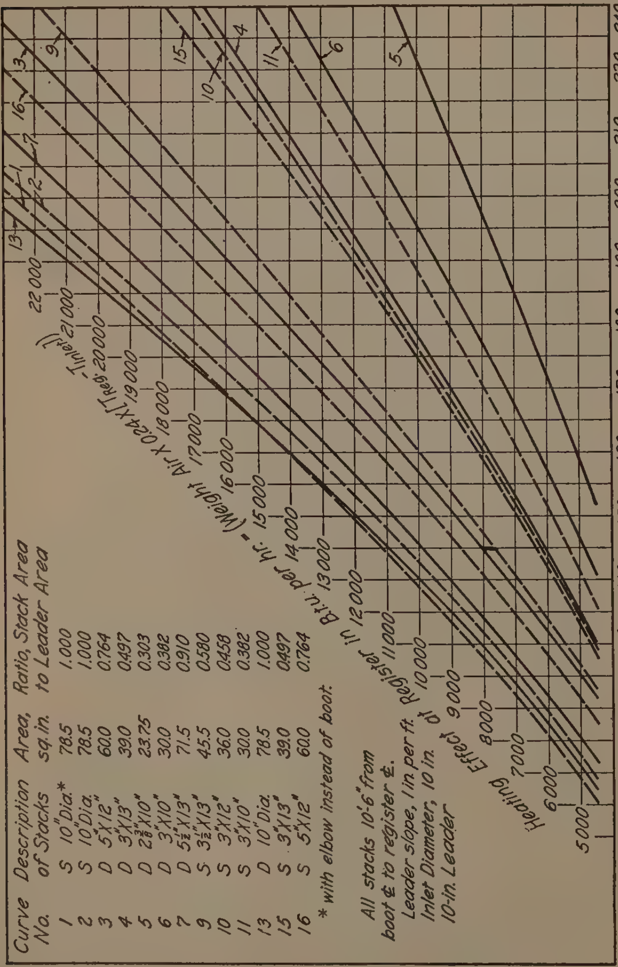


FIG. 3. RELATIVE HEATING EFFECT OF STACKS AT CONSTANT HEAT INPUT TO FURNACE

Note.—Pipe bare, bright tin except asbestos strips for joints.

WALL STACKS

The wall stack for an upper floor should be made not less than 70 per cent of the area of the leader which has been selected from Fig. 1. So long as the leader is short and straight as was the case for Fig. 1, such a practice is probably justified since the loss (Fig. 3) in capacity occasioned by the smaller stack is not very serious for stacks having areas in excess of 70 per cent of the leader area. For leaders over 8 ft. in length or for leaders which are not straight, the ratio of stack area to leader area should be greater than 70 per cent in order to offset the greater temperature losses (Fig. 2) in the longer leader. In gravity circulating systems, this stack to leader area ratio is a very important consideration. Specific data for a great variety of cases are presented



Curve No.	Description of Stacks		Area, sq. in.	Ratio, Stack Area to Leader Area
1	S	10" Dia.*	78.5	1.000
2	S	10" Dia.	78.5	1.000
3	D	5"X12"	60.0	0.764
4	D	3"X13"	39.0	0.497
5	D	2⅜"X10"	23.75	0.303
6	D	3"X10"	30.0	0.382
7	D	5½"X13"	71.5	0.910
9	S	3½"X13"	45.5	0.580
10	S	3"X12"	36.0	0.458
11	S	3"X10"	30.0	0.382
13	D	10" Dia.	78.5	1.000
15	S	3"X13"	39.0	0.497
16	S	5"X12"	60.0	0.764

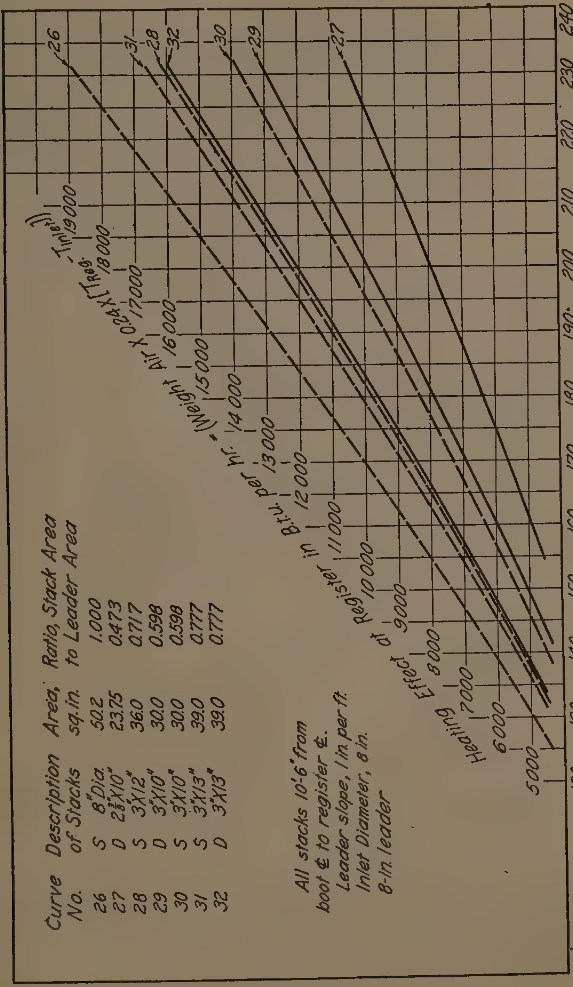
* with elbow instead of boot.

All stacks 10'-6" from boot ℄ to register ℄.
Leader slope, 1 in. per ft.
Inlet Diameter, 10 in.
10-in. Leader

Fig. 4. Heating Effect at Registers for Various Stacks with 10-inch Leader

in Figs. 4 and 5 and the designer should check the stack to leader combinations with the nearest comparable case as shown in these figures. Any second floor stack supplying heat to a room whose heat loss is 9,000

B.t.u or above (see Figs. 4 and 5 which show that high temperatures are necessary if rooms of more than 9,000 B.t.u. requirement are heated



Curve No.	Description of Stacks		Area, sq.in.	Ratio, Stack Area to Leader Area
26	S	8"Dia.	50.2	1.000
27	D	2¾"X10"	23.75	0.473
28	S	3"X12"	36.0	0.717
29	D	3"X10"	30.0	0.598
30	S	3"X10"	30.0	0.598
31	S	3"X13"	39.0	0.777
32	D	3"X13"	39.0	0.777

All stacks 10'-6" from boot ℄ to register ℄.
Leader slope, 1 in. per ft.
Inlet Diameter, 8 in.
8-in. leader

FIG. 5. HEATING EFFECT AT REGISTERS FOR VARIOUS STACKS WITH 8-INCH LEADER

by stacks in 4-in. studding), should be run within 6-in. studded walls or should have multiple stacks. Stack sections, wherever possible, should be changed from the thin rectangular to the more nearly square shape.

Stack heads should have upper end curved to provide easy flow of warm air to the room.

REGISTER AREA

The registers used for discharging warm air into the rooms should have free or net area not less than the area of the leader in the same run of piping. The free area should be at least 70 per cent of the gross area of the register. No upper-floor register should be wider horizontally than the wall stack, and it should be placed either in the baseboard or side wall, if this can be done without the use of offsets. First-floor registers may be of the baseboard or floor type with the former location preferred. No first-floor register should require a register box more than 14 in. wide, although it may be longer than 14 in.

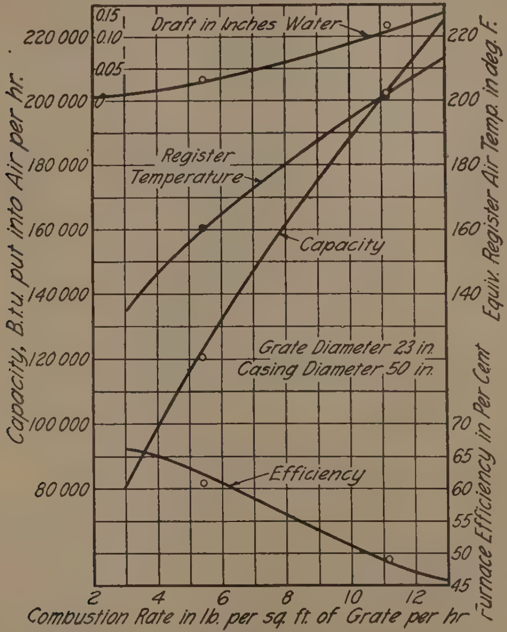


FIG. 6. TYPICAL PERFORMANCE CURVES FOR A WARM AIR FURNACE AND INSTALLATION IN A THREE-STORY TEN LEADER PLANT, OPERATING ON RECIRCULATED AIR

RECIRCULATING DUCTS AND GRILLES

The ducts through which air is returned to the furnace should be designed to minimize friction and turbulence. They should be of ample area, in excess of the total area of warm-air pipes, and at all points where the air stream must change direction or shape, streamline fittings should be employed. Horizontal ducts should pitch at least one-half inch per foot upward from the furnace.

The recirculating grilles (or registers) should have a free area at least equal to the ducts to which they connect, and their free area should never be less than 50 per cent of their gross area.

The location and number of return grilles will depend on the size, details and exposure of the house. Small compactly built houses may frequently be adequately served by a single return effectively placed in a central hall. More often it is desirable to provide two or more returns, provided, however, that in two-story residences one return must be placed to effectively receive the cold air returning by way of the stairs.

Fig 7. Elevation of the Warm Air, Research Residence

Where a divided system of two or more returns is used the grilles must be placed to serve the maximum area of cold wall or windows. Thus in rooms having only small windows the grille should be brought as close to the furnace as possible, but if the room has a bay window, french doors, or other large sources of cooling and leaking of cold air, the grille should be placed close by, so as to collect the cool air and prevent drafts. When long ducts of this type are employed they must be made oversize and favored in every way. This precaution is particularly important when long ducts and short ducts are used in the same system. The long ducts must be oversize, if they are to operate satisfactorily, in parallel with short ducts.

Return ducts from upstairs rooms may be necessary in apartments or other spaces closed off or badly exposed. Metal linings are advisable in such ducts. It is important that these ducts be free from unnecessary friction and turbulence, and that they be located to prevent preheating of the air before it reaches the furnace.

Circulation is accelerated if the drop to the furnace is through a round inclined pipe with, say, two 45-deg. elbows rather than through a vertical drop and two 90-deg. elbows. The top of the shoe should never enter the casing above the level of the grate in the furnace. To accomplish this the shoe must be wide.

SIZE OF FURNACE

The size of furnace should, of course, be such as will provide the necessary air heating capacity, usually expressed in square inches of leader pipe area, and at the same time provide a grate of the proper area to burn the necessary fuel at a reasonable chimney draft. The total leader pipe area required is easily obtained by finding the sum of the leader pipe areas as already designated.

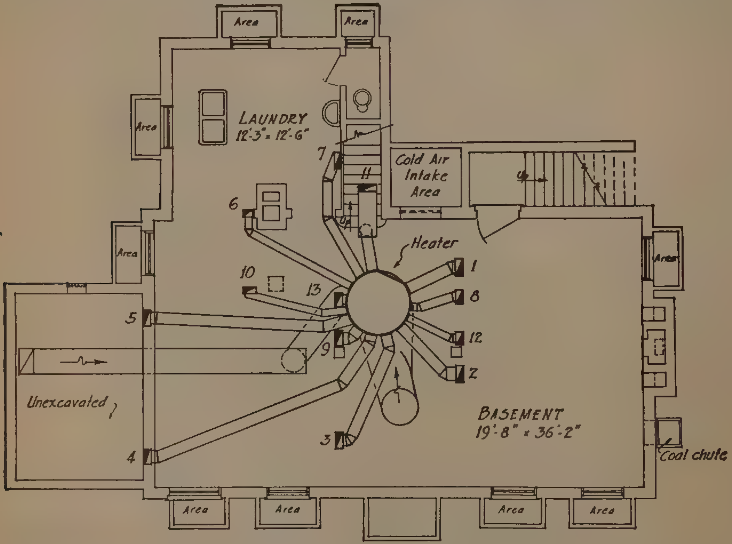


FIG. 8. BASEMENT PLAN, RESEARCH RESIDENCE

The grate area will depend on several factors of which four are very important. First of all, the air temperature at the register for which the plant has been designed must be determined. Usually, this temperature is taken as 175 deg. fahr. Second in importance is the combustion rate, *which must always correspond with the register air temperature*, as is shown by reference to a set of typical furnace performance curves (Fig. 6) for a cast-iron circular radiator furnace with a 23-in. diameter grate and 50-in. diameter casing. The conditions shown on these curves which seem to approximate nearest to the 175 deg. register warm-air temperature are—combustion rate 7 lb., warm-air register temperature 173 deg.; efficiency of the furnace 58.5 per cent. The third factor is efficiency, which, in turn, is a function of the combustion rate varying with it as shown by the efficiency curve of Fig. 6. The fourth factor is the heat value per pound of fuel burned, which was 12,790 B.t.u., but is not shown on the curves since it was constant for all combustion rates.

From the relation existing between these factors it is found (Fig. 6) that the capacity of the furnace under test is 147,750 B.t.u. per hour for the total grate, which gives the capacity at the furnace bonnet per square foot of grate as 51,300 B.t.u. and per square inch of grate as 356 B.t.u. per hour.

Suppose it is desired to select a furnace to deliver air to the rooms at a register temperature approximating 160 deg. rather than 175 deg.

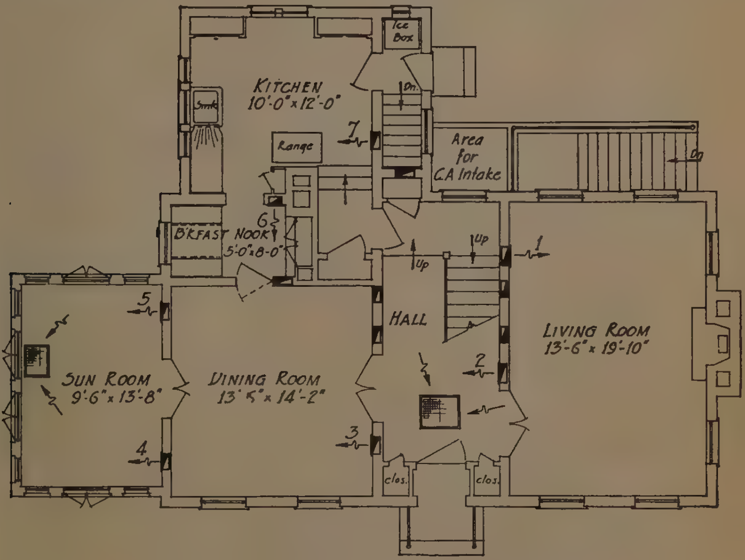


FIG. 9. FIRST-FLOOR PLAN, RESEARCH RESIDENCE

Referring to the curves, the relation is—combustion rate 5.5 lb., register warm-air temperature 160 deg. and efficiency of the furnace 62 per cent. Under this condition the capacity of the furnace at the furnace bonnet per square foot of grate area is 43,300 B.t.u. per hour, and per square inch of grate it is 300 B.t.u. per hour. From these performance values, the grate area for any plant requirement will be, (allowing 20 per cent heat loss between furnace and registers):

$$\text{Grate area (175 deg. register temperature), square inches } \frac{1.2\,H}{356} = 0.0034H^{1} \quad (7)$$

$$\text{Grate area (160 deg.), square inches} = \frac{1.2\,H}{300} = 0.0040H^{1} \quad (8)$$

---

[1] Let H = B.t.u. heat loss from the entire house per hour = summation of all room losses $H_1 + H_2$ + etc. + the B.t.u. necessary to heat the fresh air if any, at intake. This fresh air loss in B.t.u. will be

approximately 1.27 times the cubic feet of air admitted through the intake per hour on a zero day. For systems which recirculate all the air this value will be zero. For systems which have a fresh air intake, controlled by damper, this value might well be approximated, since this loss will probably be reduced to a minimum on a zero day. Assume for such cases, that the building loss is increased by 25 per cent, and that there is the usual 20 per cent loss between furnace and registers.

It is not always possible to obtain performance curves, and the following method is suggested as being a close check. An addition of 2 per cent of the furnace capacity is proposed for each unit that the heating surface-grate area ratio of the furnace exceeds 20. This addition is based on tests of four types of furnaces having various ratios of heating surface to grate area, at the University of Illinois.

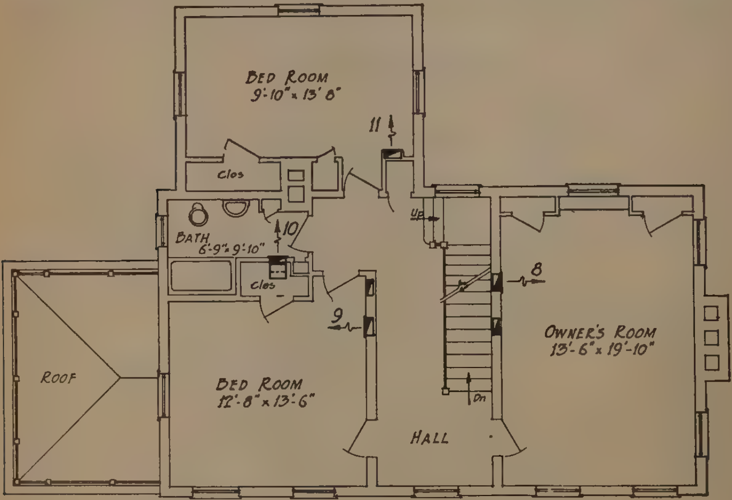


FIG. 10. SECOND-FLOOR PLAN, RESEARCH RESIDENCE

Let E = efficiency of the furnace.

f = fuel value of the coal, B.t.u. per pound.

p = pounds of coal burned per square foot grate per hour.

R = ratio of heating surface to grate area.

H = total heat requirements of the house.

$$\text{Grate area, square inches} = \frac{1.2 \times 144\, H}{Efp\,[1 + 0.02\,(R - 20)\,]} \text{ for all inside air} \qquad (9)$$

For coal having a heat value of 12,000 B.t.u., a furnace having 60 per cent efficiency, and 6-lb. coal burned per square foot grate per hour, and 20 sq. ft. of heating surface for 1 sq. ft. of grate this becomes:

$$\text{Grate area, square inches} = \frac{1.2 \times 144\, H}{0.60 \times 12{,}000 \times 6} \text{ for all inside air} \qquad (10)$$

and for another furnace having 24 sq. ft. of heating surface for 1 sq. ft. of grate the expression is

$$\text{Grate area, square inches} = \frac{1.2 \times 144\,H}{0.60 \times 12{,}000 \times 6\,[1 + 0.02\,(24 - 20)]} \tag{11}$$

The air temperatures at the registers corresponding to the conditions of equation (11) would be approximately 165 deg. fahr. and for 175 deg. fahr. and 12,000 B.t.u. the combustion rate would be about 7.5 lb. with an efficiency of 57 per cent, using the curves of Fig. 6 as a guide.

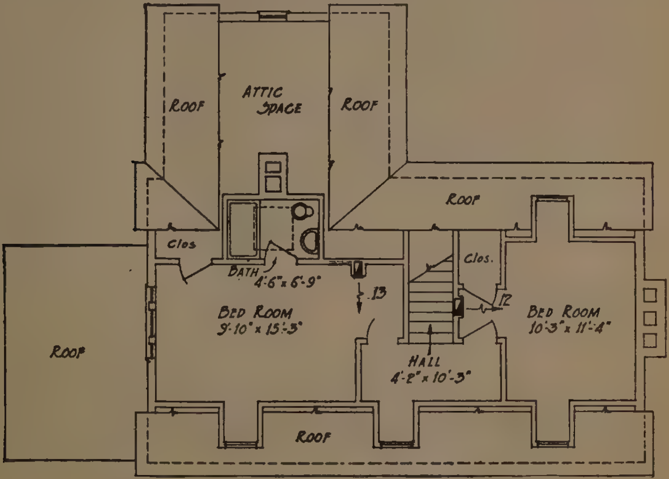


FIG. 11. THIRD-FLOOR PLAN, RESEARCH RESIDENCE

APPLICATION OF DATA

The application of the preceding data to an actual example may be of assistance to the designer. Figs. 7, 8, 9, 10 and 11,[2] represent the plans of the Warm Air Research Residence of the *National Warm Air Heating Association* erected at the University of Illinois.

Leaders, Stacks and Registers. (Direct Method)

Living Room, 1st floor:

17,250 ÷ 111 = 155 sq. in. leader area. See summary, Table 1; also Example under Standard Code, Art. 3, Basis of Working rules for pipes.

Leader diameter = 14 in.

Register size = 155 sq. in. net area. Gross area = say 1.6 × net area = 14 × 18 in.

Owner's Room, 2nd floor:

15,030 ÷ 167 = 90 sq. in. leader area. See Summary Table; also Example under Standard Code, Art. 3, Basis of working rules for pipes.

---

[2] Plans used with permission. Bath room on third floor not heated at present.

Leader diameter = 11.4, say 12 in.
Stack area = 0.7 × 90 = 63 sq. in. = say 5 × 12 in.
Register area = 90 sq. in. net area. Gross area = 1.6 × net area = 12 × 12 or 12 × 14 in.

In like manner the leaders, stacks and registers are calculated for each room in the house.

Leaders, Stacks and Registers. (Code Method. See Art. 3, Sec. 1, 2, 3)

Living Room (Glass = 90, Net wall = 405, Cubic contents = 2405)

$$\text{Leader} = \left(\frac{90}{12} + \frac{405}{60} + \frac{2405}{800}\right) 9 = 155 \text{ sq. in.}$$

Register, same as Direct Method.

Owner's Room (Glass = 68, Net wall = 394, Cubic contents = 2275)

$$\text{Leader} = \left(\frac{68}{12} + \frac{394}{60} + \frac{2275}{800}\right) 6 = 90 \text{ sq. in.}$$

Stack and Register, same as Direct Method.

Assuming all air recirculated, the minimum furnace for the plant will be:

Grate Area = 0.0034 × 132,370 = 450 sq. in. = 24 in. diam. at 175 deg. register temperature. (7)

Grate Area = 0.0040 × 132,370 = 530 sq. in. = 26 in. diam. at 160 deg. register temperature. (8) (10)

If provision shall be made for certain outside air circulation, then increase the building heat loss by, say 25 per cent and obtain by equation (7) a 27-in. grate and by equations (8) and (10) a 29-in. grate.

TABLE 1. SUMMARY OF DATA APPLIED TO WARM AIR RESEARCH RESIDENCE

Rooms	From Chapter 2 on Heat Losses from Buildings B.t.u. Heat Losses *H*	Leader Area Sq. In.	Stack Area Sq. In. 0.7 × *LA*	Leader Diameter Inches	Stack Size Net	Register Size Gross
First Floor		$= 0.009H$				
Living	17250	155	----	14	....	14 × 18
Dining	6810	61	----	9	....	8 × 12
Breakfast	2300	21	----	8	....	8 × 10
Kitchen	9210	83	----	11 or 12	....	12 × 14
Sun	25710	230	----	Two 12	....	Two 12 × 14
Hall and stair	12570	113	----	12	....	12 × 14
Second Floor		$= 0.006H$				
Owners	15030	90	63	11 or 12	5 × 12	12 × 14
S. W. Bed	9800	59	41	9	3½ × 12	8 × 12
Bath	2450	15	10	8	3 × 10	8 × 10
N. Bed	14800	89	62	11 or 12	5 × 12	12 × 14
Third Floor		$= 0.005H$				
E. Bed	8220	41	29	8	3 × 10	8 × 10
W. Bed	8220	41	29	8	3 × 10	8 × 10

STANDARD CODE REGULATING THE INSTALLATION OF GRAVITY WARM AIR FURNACES IN RESIDENCES[3]

SIXTH EDITION

March 1, 1929

ARTICLE No. 1.—Meaning of the Term "Gravity Warm Air Furnace Heating System"

Gravity Warm Air Heating Systems, to which this code refers, shall consist of one or more warm-air furnaces, enclosed within casings, together with necessary appurtenances thereto, consisting of warm-air pipes and fittings; cold air or recirculating pipes; ducts, boxes and fittings; smoke-pipes and fittings; registers, borders, faces and grilles; the same being intended for heating buildings in which they may be installed.

ARTICLE No. 2.—Certified Measurements

Certified measurements on warm-air furnaces together with the name and number of that furnace, will be issued by authority of the *National Warm Air Heating Association*, when, if and as, the grate areas and heating surfaces have been accurately measured and approved by the Research Advisory Committee.

ARTICLE No. 3.—Method for Determining Size of Warm Air Pipes, Wall Stacks and Furnaces for Use in Residences

Method for Determining Sizes of Basement Warm Air Pipes

Section 1. Each First-Floor Room:

Divide square feet of glass by 12
Divide square feet of net outside wall by factor in Table A
Divide cubic contents by 800
Add together the above and multiply by 9
The result is the area of the basement pipe in sq. in.

Stated as an equation, this is:

$$\left\{\begin{array}{l}\text{The sum of:}\\ \text{Glass (sq. ft.) (\textit{Note 1})} \div 12\\ \text{Net Wall (sq. ft.) (\textit{Note 2})} \div \text{factor in Table A}\\ \text{Cubic Contents} \div 800\end{array}\right\} \times 9 = \text{area of basement pipe}$$

Section 2. Each Second-Floor Room:

Divide square feet of glass by 12
Divide square feet of net outside wall by factor in Table A
Divide cubic contents by 800
Add together the above and multiply by 6
The result is the area of the basement pipe in sq. in.
(See Section 9, *c*)

Stated as an equation, this is:

$$\left\{\begin{array}{l}\text{The sum of:}\\ \text{Glass (sq. ft.) (\textit{Note 7})} \div 12\\ \text{Net Wall (sq. ft.) (\textit{Note 2})} \div \text{factor in Table A}\\ \text{Cubic Contents} \div 800\end{array}\right\} \times 6 = \text{area of basement duct}$$

Section 3. Each Third-Floor Room:

Divide square feet of glass by 12
Divide square feet of net outside wall by factor in Table A
Divide cubic contents by 800
Add together the above and multiply by 5
The result is the area of the basement pipe in sq. in.

Stated as an equation, this is:

$$\left\{\begin{array}{l}\text{The sum of:}\\ \text{Glass (sq. ft.) (\textit{Note 1})} \div 12\\ \text{Net Wall (sq. ft.) (\textit{Note 2})} \div \text{factor in Table A}\\ \text{Cubic Contents} \div 800\end{array}\right\} \times 5 = \text{area of basement duct}$$

---

[3] This Code is approved and issued by authority of the *National Warm Air Heating Association*, THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *National Association Sheet Metal Contractors*. First edition, October 1, 1922; 2nd edition, February 1, 1923; 3rd edition, June 1, 1924; 4th edition, May 1, 1927; 5th edition, March 1, 1928; 6th edition, March 1, 1929.

Basis of Working Rules for Pipes

(Sections 1, 2, 3)

a. These formulae are for 70 deg. temperature difference (outside temperature zero, inside temperature 70 deg. Fahr.) When temperature difference is more than 70 deg., add 1½ per cent per deg. to final figures. When temperature difference is less than 70 deg., deduct 1½ per cent per deg. from final figures.

b. The values as given in Table A for use in the working rules, Article 3, Section 1, 2 and 3 are derived as follows:

Example: The unit of calculation adopted for this is the equivalent of 1,000 B.t.u. transmitted. Any other number than 1,000 might be selected if desired and the result would be the same. Calculations are based on the commonly accepted data for heat loss through different types of walls.[4] Thus, the factor 60, Item No. 1, Table A, is obtained in the following manner: The rate of heat transmission through a wall consisting of siding, paper, sheathing, studding, lath and plaster, is 0.238 B.t.u. per square foot, per hour, per degree difference between room and outside temperatures. At 70 deg. inside and zero outside, 1 sq. ft. of wall will transmit 0.238 × 70 = 16.66 B.t.u. per hour. 1,000 B.t.u. will then be lost through 1,000 ÷ 16.66 = 60 sq. ft. of wall. Since it is found from experiment that 1 sq. in. of first-floor leader pipe delivers 111 B.t.u., it will require 1,000 ÷ 111 = 9 sq. in. to compensate for the loss through 60 sq. ft. of wall. From this we derive the formula:

$$\frac{W \times 9}{60} = \text{area of first-floor leader.}$$

Substituting 167 for the second floor and 200 for the third floor in place of 111, gives the factors 6 and 5, respectively.

Other values in Table A for the different types of walls were obtained by substitution of proper coefficient of heat transmission for 0.238 in the above formula.

TABLE A[4]

(The factor 60 used in the foregoing example is for buildings constructed as in Item No. 1. When other types of walls are used substitute the appropriate factor as given below):

Exposed Walls

No. 1.—Frame wall constructed of siding, paper, sheathing, studding, lath and plaster	60
No. 2.—Frame wall constructed of siding or stucco direct to sheathing (no paper), lath and plaster,	52
No. 3.— 9 in. Brick Wall, no plaster	40
No. 4.— 9 in. Brick Wall, plastered one side	48
No. 5.— 9 in. Brick Wall, air space, furred and plastered	65
No. 6.—13 in. Brick Wall, no plaster	53
No. 7.—13 in. Brick Wall, plastered one side	57
No. 8.—13 in. Brick Wall, air space, furred and plastered	75
No. 9.— 4 in. Brick, 4 in. hollow tile, plastered	55
No. 10.— 4 in. Brick, paper, sheathing, studding, lath and plaster (brick veneer)	68
No. 11.— 8 in. Hollow tile, stucco and plaster	52
No. 12.— 8 in. Hollow tile, stucco furred and plastered	75

Roofs

No. 13.— 1 in. T & G Sheathing Tar and Gravel	48
No. 14.— 1 in. T & G Sheathing and Composition roof	40
No. 15.— 1 in. T & G Sheathing and Tin	24
No. 16.—Corrugated Iron on strips	9.3

Ceilings

No. 17.—Lath and plaster without floor above	50
No. 18.—Lath and plaster with tight floor above	90
No. 19.—Metal without floor above	40
No. 20.—Metal with tight floor above	70

---

[4] The heat transmission factors upon which Table A is based do not in all cases agree with the factors given in Chapter 2 of THE GUIDE.

Explanatory Notes

Note 1.—In obtaining glass surface use full casement opening. An outside door is figured as glass.

Note 2.—To obtain net outside wall, multiply height by width and deduct the glass in all windows and outside doors as obtained in Note 1. For all rooms with attic spaces immediately above, full ceiling areas shall be taken into account, using Table A. Floors over unexcavated spaces shall be figured as 50 per cent exposed wall and fully exposed floors shall be figured as 100 per cent exposed wall.

Note 3.—For rooms having unusual exposure, ordinarily north, northeast and northwest, add 15 per cent to pipe area. For east and west exposure, add 10 per cent.

Note 4.—Use no basement warm-air duct less than 8 in. in diameter. If a basement warm-air duct figures greater area than any standard commercial size then the nearest commercial size shall be used, provided however, that the total duct area shall in no case be less than the total requirements according to Sections 1, 2 and 3.

Note 5.—It is understood in using the above values for determining basement warm-air duct areas, that these ducts should be run comparatively straight and that they should not be over 12 ft. in length. Sharp turns and long ducts should have extra capacity. When warm-air ducts exceed 12 ft. in length or have more than two 90 deg. turns the next larger commercial size must be used.

Note 6.—The value of 800 (used in cubic contents) is for an estimated air change of one room volume per hour. If it is desired to provide for one and one-half room volume use the figure 600. If for two-room volumes use the figure 400.

Method for Determining Size of Wall Stacks

Section 4. First Floor Rooms.

Same as Section 1.

Section 5. Second Floor Rooms.

Not less than 70 per cent of basement pipe area as determined in Section 2.

Section 6. Third Floor Rooms.

Not less than 70 per cent of basement pipe area as determined in Section 3.

Where two or more rooms are heated from the same basement pipe and stack, the area of such basement pipe and stack shall equal the combined areas as determined in Article 3, Sections 1, 2 and 3.

Transition Fittings to Stacks

Section 7. (*a*) Transition from warm-air pipes to stacks or register heads shall be made with a well-designed elbow or boot and no stack shall be less than 70 per cent of the area of the warm-air pipe leading to it.

b. All first-floor fittings and connections shall maintain a free area equal to the round basement pipes leading to them.

Method for Determining Size of Registers

Section 8. All registers shall have a free area at least equal to the area of the basement pipes leading to them.

Method for Determining Size of Furnace

Section 9. (*a*) Add together the areas (expressed in square inches) necessary for heating the building, as determined by the foregoing **calculated** requirements, Art. 3, Secs. 1, 2 and 3, and install a furnace, rated by the following formula:

Furnace Rating Formula

$$L = 1.75\,G\,[\,1 + 0.02\,(R - 20)\,]$$

L = square inches of warm-air pipe connected to the furnace as calculated.

G = grate area in square inches; the area of the firepot at the grate level; its most restricted area.

R = ratio of heating surface area to grate area;

1.75 = a constant based upon the results obtained in the Association Research on a furnace having 20 sq. ft. of heating surface for each square foot of grate, and including factors for:

E = efficiency of heater;
C = combustion rate;
F = calorific value of fuel;
0.75 = percentage of heat available at registers;
136 = B.t.u. delivering value of 1 sq. in. of pipe, assuming half of the heat is sent to each floor. This value is based on an operating temperature of 175 deg. fahr. at the register.

The formula allows 1.75 sq. in. of warm-air pipe area for each square inch of grate area, for the furnace having a ratio of heating surface to grate surface of 20 to 1. For furnaces having other ratios of heating surfaces to grate surface, it adds 2 per cent or deducts 2 per cent for each unit above or below a ratio of 20.

Application:

		No. 1 Positive Correction	No. 2 No Correction	No. 3 Negative Correction
Grate area, square inch.	=	346	346	346
Heating surface area, square inch.	=	7540	6920	5665
Ratio heating surface area to grate area	=	21.8 to 1	20.0 to 1	16.4 to 1
$R - 20$	=	1.8	0.0	−3.6
Correction per cent	=	3.6	0.0	−7.2
$1.75\,G$	=	606	606	606
$L = 1.75\,G +$ correction	=	628	606	562

a. In second-floor duplex, flats or apartments where separate heating plants are used, add 50 per cent to the total net *calculated* areas as determined in Art. 3, Sec. 2. This represents the required warm-air pipe capacity in square inches of the furnace for the second floor.

b. Every warm-air furnace shall be equipped with a water pan or other humidifying device.

c. In the application of any gas or oil fired furnace to any warm-air heating system, any deviation from the Standard Code shall apply only to the furnace itself.

ARTICLE No. 4.—Installation—Location of Furnace

Section 1. The location of the furnace shall equalize the length of warm-air runs as far as possible, yet give necessary preference to pipes supplying living rooms, dining rooms and main halls.

Foundation

Section 2. (*a*) The furnace foundation must be provided by the owner or building contractor as outlined in Art. 5 (*f*).

b. Where it is necessary to place a heater on a combustible floor, not less than 4 in. (4″) of hollow tile shall be used in every instance, having joints matched in such a way that air passage will be free from side to side, so that at no time will the removal of ashes or the handling of coal close up these openings. Such foundation shall be constructed upon, and covered with continuous sheet metal plates, of not less than No. 24 gauge metal, having all joints substantially riveted or double seamed and the bottom sheet to have the edges turned up at least one inch. This floor covering shall extend under the whole of the firebox and ashpit of the furnace and outwardly not less than two feet on all sides.

Setting or Assembling of Furnace

Section 3. (*a*) The base ring of any portable warm-air furnace shall be cemented to the foundation, and cement flushed in around the back of the base ring, making an air-tight joint. The furnace parts shall be assembled plumb and level, and in a workmanlike manner.

b. All sections and joints shall be properly fitted. Joints requiring cement shall be well filled and all bolts shall be drawn up tightly.

Casings

Section 4. (*a*) Warm-air furnaces shall be enclosed in metal casings or walls of brick, tile or concrete.

b. Portable. Sheet metal casings including casing tops or bonnets shall be made of galvanized sheets, not lighter than 26 U. S. standard gauge. They shall fit the castings and casing rings closely, so as to be dust-tight, and shall be securely fastened to the front. The casing shall be lined from the upper casing ring down to a line on a level with the grate.

c. When side collars are used the casing top or bonnet must be of sufficient height so that the largest warm-air pipe can be taken from side without ovaling. In no case shall a distance less than eight inches (8″) be maintained between the top of any furnace and the bonnet.

d. Any furnace, the casing top of which shall come within twelve inches (12″) of a combustible floor, ceiling or joist, shall be protected by a metal shield, extending not less than eighteen inches (18″) beyond the casing of said furnace. This shield shall be suspended at least two inches (2″) below woodwork, allowing free air space between shield and woodwork. No furnace casing or top, coming nearer than six inches (6″) of ceiling or joists shall be allowed in any case. All metal casing tops shall be insulated with an air space, or covered with magnesia, asbestos boiler covering, or sand.

e. Openings for side casing collars shall be cut into the casing top or bonnets, so that the tops of all openings are on a level. Casing collars shall be fitted into place with a proper flange, or bead on the outside and drawn up on the inside, making a dust-tight joint. All collars shall be of same size as the warm-air pipes to which they are to be connected.

f. Brick, cement or hollow tile casings shall be constructed as follows: Walls shall be not less than eight inches (8″) in thickness, and shall be constructed air-tight. The least inside dimension of rectangular casings shall be the same as that of the portable casing of a corresponding size of furnace. Walls shall be carried to the same height as the portable walls, allowing not less than eight inches (8″) between the top of the furnace and the bottom of the top cover. After placing the collars for the warm-air pipes, continue the masonry up two inches (2″) above the top of the collars, lay single or tee irons across the furnace top, spaced eight inches (8″), cover these with sheet metal not less than 26 U. S. standard gauge, cover the sheet metal with masonry or sand and run the side walls four inches (4″) above the roof of the furnace. A galvanized iron casing bonnet may be used on a brick set furnace.

Provision shall be made in the walls for a manhole to give ingress to heater.

Warm Air Pipes in Basement

Section 5. (*a*) All warm-air pipes shall be made of bright tin not lighter than IC, or galvanized iron. Side seams shall be locked seams. All joints shall be either double-seamed or lapped not less than one and one-quarter inches (1¼″) and such joints shall be match-beaded or beaded and soldered or riveted. All pipes and fittings shall be properly secured to ceiling or joist. No solder or riveted joint is required where round pipe slips over the casing collar or enters boot or box. Any pipe twelve inches (12″) or greater in diameter shall not be made of material lighter than IX tin or No. 26 U. S. standard gauge galvanized iron.

b. All warm-air pipes in the basement shall have an upward pitch of not less than one inch (1″) per running foot.

c. No warm-air pipe shall run within one inch (1″) of any woodwork unless such woodwork is covered with asbestos paper and the paper covered with tin or iron.

d. All warm-air pipes in the basement shall be provided with dampers supported on both sides not more than two feet (2′) from the casing.

e. Where warm-air pipes pass through a masonry wall, a metal thimble shall be provided, having a diameter at least one inch (1″) greater than the pipe, and pipe supported in such a manner that the air space is uniform on all sides.

Wall Stacks

Section 6. (*a*) Single Stacks. All single wall stacks or wall pipes, heads, boots, ells, tees, angles and other connections shall be made of tin or galvanized iron and shall be covered with not less than one thickness of 12 lb. per one hundred (100 sq. ft.) square feet of asbestos paper. All such pipes shall be braced in a proper manner so as not to obstruct the flow of air but to retain the full capacity throughout. All joints shall be locked and held in place by means of lugs, or straps. No joint, either horizontal or vertical, shall depend wholly upon solder to make it tight.

Note 7.—As an added safety factor, it is recommended that all studding and other woodwork facing said pipe be lined with metal and metal lath be used in place of wood lath. An air space of not less than five-sixteenths (5⁄16″) of an inch shall be allowed on the two sides nearest the vertical studs.

b. Double Stacks. All double wall stacks or wall pipes, heads, boots, ells, tees, angles and other connections shall be made of tin, not lighter than IC or galvanized iron and shall be made double, from and including the boot or foot piece in basement to the top of each and every stack and register head on all floors. There shall be continuous uniform air space of not less than five-sixteenths (5⁄16″) of an inch, which must be maintained between the outer and inner walls of all such pipes and fittings of all kinds, styles and descriptions; such pipes, heads, boots and other fittings to be of the styles, or equal to those accepted by the *National Board of Fire Underwriters.*

c. All stacks and fittings, either single or double, must be secured firmly in place by lugs or straps attached to the outer walls of stacks and fittings, and no nails shall be driven through these stacks or fittings at any point. No lugs or straps shall be formed by cutting holes in outer walls of stacks or fittings. No wall pipes or fittings shall be used which depend wholly on soldered joints. The various members shall be so made that all joints are locked or soldered and the several members shall be attached to each other with slip joints which are for the purpose intended—air-tight.

d. Where stacks, heads, boots or other fittings, whether double or single, go through the first floor, all openings around such heads, boots, stacks or fittings must be filled with asbestos cement or other incombustible material to make the openings gas and dust tight.

Registers

Section 7. (*a*) When baseboard or wall registers are used, they shall be properly and permanently attached to the stack head in such a manner that will prevent any leakage of air between the head and the register.

b. Floor registers shall be provided either with register borders, or double register boxes of tin or galvanized iron with an air space of not less than five-sixteenths (5⁄16″) of an inch between inner and outer boxes.

c. Registers for warm air and warm-air pipes shall not be located in outside walls, unless properly insulated with one-inch (1″) air cell covering or its equivalent.

d. Any furnace system having not more than two warm-air openings, at least one of these openings shall have a grille and the pipe thereto shall be without damper.

Air Supply to Furnace

Section 8. (*a*) The air supply to furnace for warm-air heating plants may be taken from outside or from within the building or may be taken partially from outside and partially from within. In no case, however, shall air be supplied to any furnace from any basement or furnace room not occupied as living quarters.

b. The cold air intake or return where air is taken from within the building shall have a net area throughout its entire length of not less than the combined net area of all warm-air pipes leading from the furnace. This may be maintained in one or more ducts. No reverse incline or air trap will be allowed in any section thereof.

c. When the cold air supply is taken wholly from the outside of the building the supply duct at its most contracted area must equal or exceed eighty per cent (80%) of the combined area of all warm-air pipes leading from the furnace.

d. Cold air ducts shall be constructed of metal, tile or other incombustible material having smooth inner surface and shall maintain a constant net area throughout their entire length and shall be made dust-tight. Horizontal rectangular return ducts shall have at least 10 per cent (10%) greater area than vertical connecting pipes. Where a boot or shoe is connected to the casing at the base, the opening shall not extend higher than a line on the level of the top of the grate of the furnace. The width of the shoe shall be of proper measurement to make the area at least equal to that of the round or square pipe to which it is connected.

e. Wherever the space between joists is used to convey cold air over head, all bridging and bracing shall be removed and a sheet metal pan shall be constructed to extend not less than two inches (2″) below said joists. The connection from this pan to the boot or shoe shall be made of galvanized iron not lighter than No. 26 U. S. standard gauge, and shall have a transition collar, the top area of which shall be at least 10 per cent (10%) greater than the area of the connecting pipe.

Note 8.—To reduce friction, and for the sake of cleanliness it is recommended that the joists and all wooden surfaces between such joists shall be lined with metal.

f. When it is necessary to set the furnace over a pit and connect up cold air under the basement floor, such pit or cold-air trench shall not exceed eighteen inches (18″) in depth below the casing base-ring and the width of the trench or trenches shall be of proper measurement to make the area at least equal to the pipe to which it is connected. The connection between the cold-air pipe or duct and the underground pit shall be made with reverse transition joint as described in (*e*) of this section.

g. The cold air face or faces shall be made of wood or metal. When set in floors the top of same shall be flush with floor. Where cold air face is placed in a seat or side wall (whether furnished by owner, general contractor or furnace contractor) the open work of face must extend to within at least one inch (1″) of the floor line.

The free area of cold air faces shall be at least equal to the free area of the duct or ducts to which they are connected.

h. The effective area of a vertical cold air face lies within fourteen inches (14″) of the floor line, hence, the capacity of any vertical cold air face shall be determined by multiplying the base line in inches by not to exceed fourteen inches (14″) in height and deducting for the grilles or cross bars.

i. When a fan is installed in the air supply duct of a gravity system the same net area of all ducts shall be maintained as calculated under Article 3, Sections 1, 2 and 3 and Article 4, Section 8–(*b*).

Smoke Pipes

Section 9. (*a*) The smoke pipe shall be as short and direct as consistent with the location of the furnace. It shall be made of metal not lighter than No. 24 U. S. standard gauge, and not less than the full size of the collar on the furnace throughout its entire length. It must have no opening for attaching any fireplace, stove, range, water heater, gas or ventilating connection. It shall be lock-seamed or riveted; all joints shall lap not less than one and one-half inches (1½″) and it shall be rigidly secured. Cast iron smoke pipe may be used.

b. All smoke pipes shall be provided with check dampers, placed on the side of the pipe or at the end of a tee; when cast iron smoke pipe dampers are used they must be placed between the check damper and the furnace and supported on both sides of the pipe.

c. Where the smoke pipe enters the flue, a thimble shall be cemented into the flue and the connections thereto made air-tight, see Article 5, (*c*). Should any smoke pipe come within eighteen inches (18″) of any combustible material, such combustible material must be covered with asbestos paper and a metal shield so fastened that a two-inch (2″) air space exists between this shield and the combustible material. This shield shall be no less in size than twice the diameter of the smoke pipe and of sufficient length to cover the combustible material at all points.

d. No smoke pipe shall project through any external wall or window. No furnace connection is to be made to a flue without a cast iron or steel cleanout having first been provided in the flue (not more than eight inches (8″) below the smoke pipe opening). The base of the flue shall be filled up to the bottom of the cleanout, all of which must be made air-tight.

Pipeless or One-Pipe Furnaces

Section 10. (*a*) When but one duplex grating is used for both warm air and cold air in a so-called pipeless furnace, the area of the cold-air intake shall be at least equal to the area of the warm-air outlet of the grating. Art. 4, Sec. 4, relative to casing shall not govern when this type of furnace is installed, but the following specification shall be followed: The inner and outer casing of this type of furnace may be made of either black or galvanized iron not lighter than No. 26 U. S. standard gauge. A uniform air space shall be maintained at all points between the inner and outer casing. In no case shall the top of the heater be allowed closer than twelve inches (12″) to any ceiling or joists above the furnace.

b. Where joists are cut to accommodate this furnace, headers shall be put in and braced.

c. Art. 3 for determining area of warm-air pipe shall not govern in figuring a pipeless furnace.

d. Where one warm-air register face is used and separate face or faces for cold air supply are used, then Art. 4, Secs. 5, 7 and 8 shall apply.

ARTICLE No. 5.—The following provisions shall be made by the owner or building contractor, in any building wherein a gravity warm-air heating system is to be installed.

Chimney

Provide a chimney for the furnace constructed in a manner to comply with the following specifications:

a. The chimney must be absolutely smoke tight throughout its entire length, and must extend at least three feet (3′) above a flat roof or two feet (2′) above the ridges of peak roofs.

b. If built of a single thickness of brick or of cement blocks, it shall be lined throughout its entire length with fire clay flue lining, having not less than three-quarter inch (¾″) thickness. Flue lining to be laid in mortar and made air-tight.

c. The furnace flue must have no other opening for attaching any fireplace, furnace, stove, range, water heater, gas or ventilating connection. The chimney thimble shall be furnished and installed by owner or building contractor, of the size and in the location specified by the Heating Contractor.

d. If necessary to offset the flue, it must be done in such a manner as not to reduce the cross sectional area or create a ledge or obstruction, where loose material may lodge.

e. The narrowest internal dimension shall be not less than eight inches (8″) and no flue smaller than eight by eight inches (8″ x 8″) rectangular or eight inches (8″) diameter round will be considered suitable when hard coal is to be burned, or eight by twelve inches (8″ x 12″) rectangular or ten inches (10″) round for soft coal or wood.

Note 9.—It is strongly recommended that nothing less than 8 x 12 in. internal dimensions be used in any case.

Note 10.—It is recommended that the height above the furnace grate be not less than 26 ft.

Note 11.—It is strongly recommended that all new chimneys be built in strict accordance with the ordinance recommended by the *National Board of Fire Underwriters.*

Furnace Foundation

f. Furnace foundation of brick, cement, or other like incombustible material must be provided. Said foundation shall extend at least fifteen inches (15″) at rear and sides of furnace casing and at least thirty-six inches (36″) in front of furnace casing. Foundation to be level. (See Art. 4, Sec. 2).

Building

g. Where warm-air register boxes, heads, pipes or stacks are to be installed, joists shall be set not less than sixteen inches (16″) on centers and shall be butted and not lapped. Studding shall be set directly over and under joists, leaving a space of not less than fourteen inches (14″) between studs and joists. Wherever joists are cut, headers must be put in to support joists.

h. All first-story single or sub-floors shall be continuous. In all houses having studded exterior walls, these floors shall be extended to the outside sheathing and all spaces between studding shall be closed at the attic line.

Note 12.—It is strongly recommended that the attic be tightly floored or ceilings insulated to reduce heat losses.

i. All partition walls (or sections of these walls) in which heat stacks to second or third floor rooms are to be installed, shall be of sufficient size to accommodate stacks required to heat said rooms.

FORCED OR BOOSTER CIRCULATION

Experiments at the University of Illinois[5] have shown that the capacity of a furnace may be increased nearly three times by an adequate fan, with a constant register or delivery temperature maintained, *provided that the rate of fuel consumption can be increased to provide the necessary heat.* In other words, the capacity of a forced circulation system *is limited by the ability of the chimney to produce a sufficient draft.*

Booster fans often may be arranged to operate when the gas and oil burners operate and to stop automatically when the burners shut down. The booster equipment is most effective in increasing output at low operating temperatures. According to tests, efficiencies may be advanced from 60 per cent for gravity to 70 per cent with boosters at low operating temperatures, but at high operating temperatures gravity and booster efficiencies are almost identical.[6]

---

[5] See University of Ill. Eng. Exp. Sta. Bul. 120, p. 129.

[6] See Univ. of Ill. Eng. Exp. Sta. Bul. 141, p. 79.

CHAPTER 6

HEATING WITH WARM AIR FURNACES BY FAN PRESSURE

Fan-Furnace Systems for Large and Small Buildings; Ratings, Design, Selection and Arrangement of Heaters; Fuel.

THE fan-furnace heating system described in this chapter is fundamentally a warm-air system in which the air circulation is maintained by means of fans during the period heat is required. For data on booster fans in connection with gravity furnaces, see Chapter 5. For data on direct-fired fan-furnace unit heaters, see Chapter 9.

The fan-furnace system of heating provides a positive circulation of either outside air or return air over direct transmission heaters, through ducts to various rooms in the building and thence to the atmosphere by exhaust or back to the fan for recirculation. The use of fans permits warm-air heating and ventilating easily to be provided in buildings larger than those which could be handled properly by gravity alone.

When first introduced, fans were used with existing gravity furnaces, but gradually the practice developed of building furnaces particularly designed for fan service. Due to the fact that the fan could be made to deliver any given volume of air against comparatively high resistances, the free area through the fan-duty heaters could be reduced from that required by gravity heaters by interposing more heating surface in the path of the air and by creating a more intimate contact between the air and the heating surface.

Furnaces for use with fans must be designed to secure this increased heating surface, with proper fire travel and with commensurate grate area, within economical space limits. Many of the heaters of larger capacity are designed with horizontal travel of the products of combustion to secure these features and properly to care for expansion and contraction.

A fan-furnace system affords a direct transfer of heat from fuel to air, has few parts, gives quick response with high temperatures and contains no water to scale, corrode or freeze.

Heaters for fan-furnace systems usually are made of cast iron or of steel. The cast-iron furnaces are made in sections which are cemented and then bolted together on the job, and the steel furnaces are assembled with welded or riveted joints.

RATING

This class of equipment usually is rated in one of three ways, as follows:

1. The temperature rise of the air is listed over a certain range of velocities through the free area of the heater for varying combustion rates, for a certain heating value of the fuel.
2. The volume of air in cubic feet per minute is listed over several temperature rises with the necessary fuel consumption, taking coal of some known heating value as a standard.
3. The B.t.u. imparted to the air is listed for varying combustion rates.

Either of the first two methods is preferable to the third because of the inaccuracies that are apt to creep into the latter, due to the fact that for the same combustion rate on any given heater, the B.t.u. imparted to the air will not remain constant, but will vary with the volume of air passed over the heater.

The capacities of heaters for large commercial and industrial buildings range from 400,000 to 1,500,000 B.t.u per hour per unit. The capacities of heaters for residences and other small buildings range from 90,000 to 400,000 B.t.u. per hour per unit.

Efficiency of Heating Surface

The emission of heat from the heating surface of these furnaces will vary from 2,000 to 3,000 B.t.u. per square foot per hour. The average is about 2,500 B.t.u.

Ratio of Heating Surface to Grate

In commercial sizes the ratio of the heating surface to the grate surface will vary from 30 to 1 to 50 to 1.

Free Area and Resistance

The free area through the heaters and resistance to the flow of air at varying velocities are characteristics depending upon the heater in question.

FAN FURNACES FOR VARIOUS FUELS

The proper design of the heater hinges largely on the kind of fuel to be burned. Accordingly, various manufacturers are making special units for coal, oil and gas. Each class of fuel requires a distinct type of heater for the highest efficiency and economy obtainable. Briefly the characteristics of a heater to obtain the best efficiency and economy for each of the fuels are as follows:

1. COAL BURNING:
    - a. *Bituminous*—Large, open combustion spaces, and self-cleaning heating surfaces.
    - b. *Anthracite*—Large firebox capacity.
2. OIL BURNING:
    - a. Long tortuous fire travel.
    - b. Extensive heating surface.
3. GAS BURNING:
    - a. Extensive heating surface.
    - b. Numerous small flue passages.

Anthracite, semi-anthracite, semi-bituminous and bituminous coals are suitable when selected in the proper sizes. The fan-furnace system lends itself to the burning of buckwheat coal by using forced draft from a fan with grates having small air spaces. For burning small-sized bituminous coal, a stoker or a Dutch oven easily can be added.

Where oil fuel is used care must be exercised in selecting the proper size and type of burner for the particular type of heater used.

It is desirable to provide the following controls with any type of oil burner in addition to the usual house-temperature regulation:

1. A temperature limit control in the warm-air plenum space for burner cut-off in case of overheating.
2. An automatic fan-motor starter, governed by a thermostatic switch in the warm-air plenum chamber so that the fan cannot be started until after the heater is sufficiently warmed and which will cause the fan to start as soon as the heater becomes warm. It is advisable in the burning of heavy fuel oil to install an electric oil preheater unless steam is available for warming the oil in the storage tank.

A gas-burning installation should be fitted with safety devices, such as safety pilot burners and temperature limit controls in the warm-air plenum space operating in conjunction with automatic snap valves in the gas supply lines. These will function to shut off all gas to the burners in the event the pilot burners should be extinguished or if the temperature in the warm-air plenum chamber exceeds any set degree.

PROCEDURE FOR DESIGN OF FAN-FURNACE SYSTEMS

The following general procedure is recommended for the design of fan-furnace systems:

1. Calculate heat loss of each room in building: (See Chapter 2).

   Example: Assume schoolroom with cubic content 6,550.
   Heat loss = 45,269 B.t.u.

2. Determine volume of air per minute, based on number of occupants and number of air changes:

   Example: Assuming 33 occupants; 30 cu. ft. per minute per occupant.
   $33 \times 30 = 990$ cu. ft. per minute.
   $\frac{6,550}{990}$ contents = 6½ min. per air change or approximately 9 changes per hour.

3. Figure diffusion temperature of air for each room[1]:

   Example: Diffusion Temperature $= \frac{56 \times h}{60 \times v} = \frac{56 \times 45,269}{60 \times 990} = 42.3$ deg.

4. Determine required register temperature:

   Register temperature equals room temperature plus diffusion temperature:

---

[1] The diffusion temperature may be defined as the number of degrees the volume of air as determined under Item 2 must be *in excess* of the room temperature, in order to offset the heat loss by cooling over that range. In other words it is the number of degrees representing the difference between the necessary supply register temperature and the room temperature for the conditions under which the heat losses are calculated in Item 1. It is readily calculated by using the following formula:

Diffusion temperature $= \frac{56\,h}{60\,v}$ where h is the heat loss in B.t.u. per hour. v is the volume of air in cubic feet per minute measured at 70 deg. fahr. for the room in question.

Example: Assume 70 deg. room temp.
42.3 deg. plus 70 deg. = 112.3 deg.

5. Determine final temperature of air leaving heater:

Final temperature equals register temperature plus allowance for loss in ducts:

Example: 112.3 deg. register + 10 deg.
Loss in ducts = 122.3 deg.

6. Determine temperature rise through heater:

Temperature rise equals final temperature minus initial temperature. Where part outside air and part recirculated air is used, initial temperature approximately equals $P_oT_o + P_rT_r$:

P_o = percentage outside air.
T_o = temperature.
P_r = percentage recirculated air.
T_r = temperature recirculated air.

Example: Temperature rise 122.3 deg. − 0 deg. = 122.3 deg. with all outside air.
or
Assume 50 per cent outside air 0 deg.
50 per cent recirculation 60 deg.
$P_oT_o + P_rT_r = 0.50 - 0 + 0.50 \times 60 = 30$ deg. initial temperature.
Temperature rise through heater = 122.3 deg. − 30 deg. = 92.3 deg.

7. Calculate required free area through heaters[2]:

Select velocity through heaters suitable to problem.

$$\text{Free area} = \frac{\text{Total cubic feet per minute}}{\text{Velocity in feet per minute}}$$

Example.—Assume total cubic feet per minute of all rooms = 21,000.
Assume 900 ft. per minute through heater. (See Table 1.)

$$\frac{21,000}{900} = 23.3 \text{ sq. ft. free area.}$$

8. Select size and number of heaters:

Take temperature rise from item 6;
Take free area from item 7;
Assume maximum allowable combustion rate for fuel to be burned and stack available;
Note resistance of heaters for air volume;
Select suitable heaters from ratings.

9. Design duct system:

Ducts may be designed according to standard practice. (See Chapters 5 and 27).

---

[2] Some heaters are rated on the basis of the volume of air that may be warmed over any given temperature range for all heater sizes and list the static resistance in each instance. In this case the free area need not be calculated, but the combustion rate should be investigated.

10. Calculate total static pressure for entire system.
11. Select fan. (See Chapter 26 and fan manufacturers tables).
12. Select motor.
13. Select the type of power transmission from the motor to the fan.

FAN-FURNACE SYSTEMS FOR LARGE BUILDINGS

The fan-furnace system is well adapted to public and industrial buildings, including schools, churches, theaters, auditoriums, convention halls, factories, garages, and in recent years, has been much used for aeroplane hangars. In each case the building plans largely determine the type of duct system that can most advantageously be used. So far as the design of the ducts is concerned, the engineer has only to follow his customary practice in ventilating work. He may calculate the duct sizes either on the velocity basis or on the pressure-loss basis, using the same velocities, data, temperature ranges, and methods he would use in planning any other system of forced air circulation for heating and ventilation. (See Chapter 27). The ratio of the amount of outside air to the amount of recirculated air varies with different types of buildings and with the purpose for which they are used. State laws, local codes, and customary practice will govern the engineers' decision. (See Chapters 3, 4 and 7).

Selection of Heaters

In selecting heaters for any particular work, the engineer should be governed by certain considerations that arise through the nature of the service for which the plant is intended. The volume of air to be passed over and through the heaters limits the free area required in the latter, once the velocity at this point is agreed on. It will be evident that more heater capacity is required to offset the heat losses of a building with outside air than with recirculated air. Consequently when designing a plant for operation with recirculated air, the volume of air per heater will be considerably larger than would be the case for outside air. If the velocity through the heater in this case is not investigated, it may prove to be excessive, thus increasing the static resistance of the system unduly and resulting in unnecessarily increased power consumption. The free area may be increased by using wider casings, thus reducing the resistance and power consumption. In practice, velocities through the free area of the heaters are used as follows:

1. Schools, Churches, Auditoriums, Theaters, etc., from 800 to 1,000 ft. per minute.
2. Industrial Buildings, Factories and Garages, from 1,000 to 1,400 ft. per minute.

The importance of power cost affects the decision as to what free area and static resistance are allowable.

The thermal efficiency of the various makes of heaters is a consideration deserving some thought in case the fuel to be burned is relatively high in cost.

First-cost and fuel-economy are items that bear also on the type of furnace casing to be employed.

One of the most important considerations is the durability or life of the apparatus. Consideration should be given to the thickness of the metal in each heater, the provisions made for expansion and contraction, and the protection afforded the firebox at the point of most intense heat.

A heater made of thicker metal than others usually will give greater length of service, other things being equal.

Proper provisions for expansion and contraction are imperative. Without such provisions a cast-iron heater is likely to crack and a steel heater is likely to warp and buckle.

Most furnaces have linings around the periphery of the fuel bed to protect the firebox from the action of the hottest part of the fire. The linings are removable and are as easily installed as new grates.

TABLE 1. AIR VELOCITIES AND REGISTER TEMPERATURES FOR FAN-FURNACE SYSTEMS

TYPE OF BUILDING	VELOCITIES IN FEET PER MINUTE							REGISTER TEMPERATURE
	Thru Free Area of Heaters	In Horizontal Supply Ducts	In Supply Risers	Into Room	In Vent Outlets	In Vent Risers	In Horizontal Vent Ducts and Recirculating Ducts	
Schools	800 to 1000	800 to 1000	500 to 600	300 to 400	300 to 400	500 to 600	600 to 800	90° to 120°
Churches	800 to 1000	700 to 900	400 to 600	300 to 500	300 to 500	400 to 600	500 to 700	80° to 120°
Auditoriums and Convention Halls	800 to 1000	800 to 1000	500 to 600	300 to 500	300 to 500	500 to 600	600 to 800	80° to 120°
Garages and Industrial Buildings	1000 to 1400	1000 to 1400	600 to 1000	400 to 1000	400 to 600	600 to 1000	800 to 1200	80° to 140°

Arrangement of Heaters

Any number of furnaces may be set in battery; all to be enclosed by an outer casing consisting of either masonry or of some form of insulated metal. This casing provides space under the heaters for air supply and forms a plenum space above the furnaces from which ducts may lead to the rooms requiring heat.

The fan preferably is placed at the rear of the heaters to secure equal air distribution over the heating surfaces. It is considered best practice to blow air around the heaters rather than to draw the air around them by suction, and most fan furnaces are designed for this arrangement.

The fan-furnace system can be applied readily to each of the following standard duct systems or to any combination thereof:

1. The straight fan-blast trunk-line system carrying heated air only for a series of rooms on any one run.

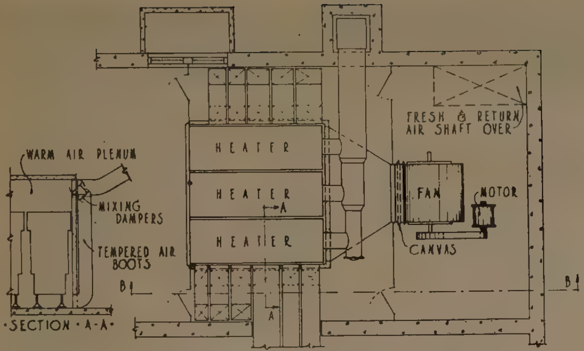


Fig. 1. Fan Furnace with Individual Ducts

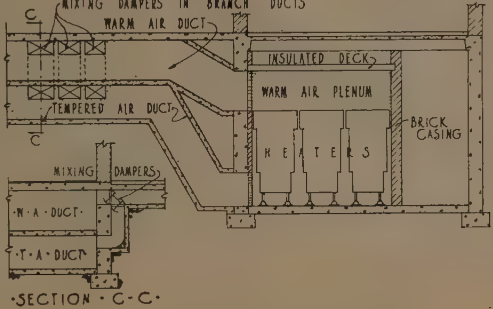


Fig. 2. Fan Furnace with Double Ducts

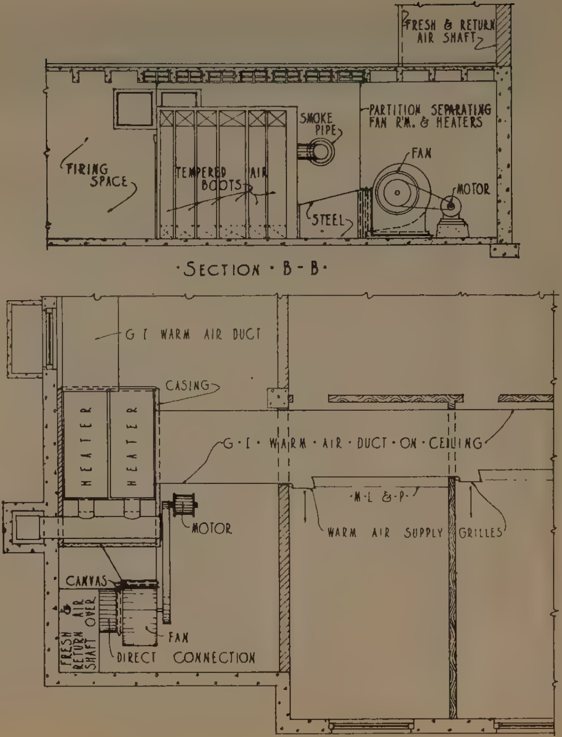


Fig. 3. Fan Furnace with Single Duct

2. The double-duct system furnishing warm air in one duct and tempered air in the other duct; the mixture to be secured near the room which is to be heated and ventilated.

3. The individual duct system with separate ducts to each room, providing mixture of warm and tempered air at the furnace casing.

The fan-furnace system utilizes automatic temperature and humidity controlling apparatus, air filters, air washers, ozone, etc., as well as does any other type of heating.

Automatic temperature control readily can be used on the trunk line system of ducts by volume control of the warm air at the supply openings, and on the double duct and individual duct systems by double-leaf mixing-damper control of the warm and tempered air. For mild climates the tempered air may be taken from the space under the furnaces; in which case the intermediate type thermostat is recommended. In colder climates the air may be tempered by conducting a portion of the warm-air supply from the plenum space over the heaters to the fan inlet, the duct connection having a damper controlled by a thermostat in the fan-outlet connection. Again, a tempered-air plenum chamber may be provided over the warm-air plenum chamber, arranged so that a double-leaf mixing damper regulates a mixture of air from the fan (by-passing the heater) and air from the warm-air plenum chamber controlled by a thermostat in the tempered-air plenum chamber.

For all plants a warm-air plenum chamber thermometer, of extension type, indicating the temperature of the air leaving the heater, is of great assistance for proper operation.

Humidifying pans connected to an outside water supply and regulated by a float-valve mechanism frequently are used for humidification. To accelerate vaporization, water coils, connected to humidifying pans, may extend inside the combustion chamber; but these must be proportioned carefully so as to prevent excessive generation of steam.

Automatic control of humidity can be secured by means of sprays or by air washers. When air washers are employed it is necessary to introduce a warm-air supply in front of the air washer or to use heated water to prevent freezing.

The use of air washers as heat transfer agents in conjunction with refrigeration installations is practical with this system for summer cooling, as with other mechanical ventilating plants. All styles of air filters not depending on water are well adapted to use with fan-furnace plants.

Wherever recirculation is used extensively, ozone may be applied with the utmost ease and facility.

FAN-FURNACE SYSTEMS FOR RESIDENCES AND OTHER SMALL BUILDINGS

The field of fan-furnace heating has been extended to include residences and other small buildings through the development of equipment which incorporates in single units all devices necessary for filtering, for humidifying, for temperature regulation, for forcing a positive delivery of the air. Some manufacturers enclose the heater, fan, filters and humidifier in a steel cabinet casing of neat appearance.

The most important advantages of the fan-furnace system for small buildings are as follows:

1. The registers may be placed in outside walls, or under windows; contrary to practice in fan gravity work.
2. The heater location need not be central, and its location may be determined by proximity to the chimney.
3. Pipes may be of small size and need not be given a slope to aid the flow.
4. Cold-air returns may be placed with a view to securing the most advantageous collection of return air without sacrificing efficiency.
5. Remote rooms may be heated satisfactorily because the system provides a positive delivery of conditioned air to each room.
6. All air may be filtered to remove dust.
7. The fan may be used for circulating air in the Summer.

Fan furnaces of this type are adaptable to either trunk line duct systems, or to central chambers or to individual pipe installations, the size and shape of the building being the governing factors. The supply of air to individual rooms may be made with small branches, 6-in. and 8-in. diameters being in common use. Risers and registers of commercial sizes in use in gravity warm-air heating practice are adequate. The general principles of proportioning ducts apply to this system as well as to other systems, but it has been found desirable to base the design on lower velocities than is the custom for larger buildings. The following velocities have been found satisfactory:

Over nominal area of registers	200–300 ft. per minute
Branches and stacks	400–600 ft. per minute
In main ducts of trunk system	500–800 ft. per minute
In returns	500–600 ft. per minute

On the basis of these velocities it has been possible to evaluate the air delivery, and hence the B.t.u. capacity of commercial pipes and fittings and, therefore, to simplify the design.

In order to secure a proper flow of air to the individual registers in a system having a central distributing chamber, orifices standardized and calibrated in terms of cubic feet may be used. In such a system the pipes may all be of one size, and balance or equalization of the flow may be fixed by the orifices.

Gas-Fired Fan-Furnace System

For gas fuel, high efficiencies have been obtained through the use of large areas of heating surface concentrated in banks of plate heaters through which the air is forced at high velocity. High operating efficiencies, further, are assured through the use of throttling gas valves, which, actuated by thermostats, proportion the consumption of fuel to the demand for heat, and thereby lessen the losses due to excessive flue temperatures and radiation. Units have been operated at efficiencies from 85 to 90 per cent.

When high efficiencies are attained in gas-fired units provision must be made for disposal of the condensation formed in the passages of the heater, and for protecting the surfaces from the corrosive action of the sulphurous or sulphuric acid formed. Further provision must be made for producing a draft in the flue pipe and for protection against the formation of condensation therein.

Data on Gas-Fired Residence Installation

The more important data for a typical gas-fired fan-furnace installation in a residence are given in the following tabulation:

1. Calculated heat losses for entire building	92,793 B.t.u. per hour
2. Capacity of furnace required (item 1 + 25 per cent)	116,000 B.t.u. per hour
3. Maximum rating of the furnace selected (input)	175,000 B.t.u. per hour
4. Minimum rating of the furnace selected at lowest throttling point	30,000 B.t.u. per hour
5. Efficiency at maximum rating	88 per cent
6. Gas consumption with gas of 550 B.t.u. per cubic foot; density of 0.50 lb. per cubic foot and pressure of 3½ in. water	318 cu. ft. per hour
7. Fan capacity at 750 r.p.m. and static pressure of 0.30 in. water	1,200 cu. ft. per minute
8. Volume of air per B.t.u. delivery	1.57 cu. ft.
9. Velocity of air at heater outlet	438 ft. per minute
10. Filter area	6.0 sq. ft.
11. Velocity of air through filter	200 ft. per minute
12. Return connection area	2.10 sq. ft.
13. Velocity through return connection	570 ft. per minute
14. Static pressure at heater outlet	0.10 in. water
15. Power input to motor	125 watts
16. Water evaporated for humidification	8.5 lb. per hour

Typical Specifications for Residence System

The following are typical specifications for fan-driven heater for a residence:

Furnace: Capacity at 5 lb. of coal per square foot of grate per hour, 118,000 B.t.u. per hour. (An automatic stoker, or gas or oil burners may be used).

Fan: Canvas connections to and from fan. Fan mounted on 2 in. corkboard. Speed, 400 r.p.m. Brake horsepower, 0.10. Capacity, 1,240 cu. ft. per minute at ¼ in. static pressure or equivalent to three times volume of house per hour.

Motor: ¼ hp., 1,140 r.p.m. *belt:* connected to fan with endless, over-size belt. Belt guarded. Motor mounted on corkboard.

Filters: Two units 20 x 20 in. Made to slide in and out as drawers and tightly fitted to prevent by-pass of air entering from basement. Furnished complete with 2 gal. of adhesive oil and charging tank.

Fan Control: Automatic mercury switch in bonnet of furnace.

Humidifier: Two cast iron water pans, enameled inside and out as well as frames and covers, complete with automatic float valve.

Thermostat: Eight-day duplex, with limit control on furnace and electric motor.

Ozonator: Forty-watt capacity.

Velocities in branches and at inlets and outlets approximately 200 ft. per minute. Velocities in main and return at furnace 413 ft. per minute.

CHAPTER 7

AIR CONDITIONING

General Requirements for Industry; Comfort; Properties of Material; Equipment; Air Distributing Systems; Controls.

AIR conditioning is the science of controlling the temperature, humidity and cleanliness of the air within an enclosure.

AIR CONDITIONING FOR INDUSTRIAL PROCESSES

Conditioning for industrial processes has become an exact science with results measurable in a more perfect product, in increased production, in elimination of waste and in other equally important benefits. Varying degrees of moisture are required in many manufacturing processes. Heating as well as cooling must be considered in the air conditioning of the buildings which house textile mills, printing plants, bakeries, candy kitchens, laundries and many other types of manufacturing.

It has long been recognized that relative humidity is an important factor in the manufacture and processing of certain hygroscopic materials such as textiles. Since the normal relative humidity in textile factories is nearly always lower than that desired, various artificial means have for many years been provided to increase the humidity.

There are other industries which require a definite and unvaried humidity, so that at some periods (minutes, or hours or seasons) the normal quantity of moisture in the air must be increased, and at other times it must be lowered. These industries include the confectionery, the artificial silk, and the printing and lithographing trades.

Other products require not only a constant relative humidity, but also a uniform temperature during the course of manufacture. For example, modern automatic wrapping machines, such as are used for wrapping chewing gum, foods, confectionery and machine-made cigarettes, require exact conditions of heat and moisture in order to function satisfactorily without frequent adjustments.

In the manufacturing and processing of most hygroscopic materials there are usually stages in the process during which moisture must be removed from the material. When the products themselves are not soluble in water, this is usually accomplished by air drying.

In order to avoid injury to the products which require temperature and humidity control, the rate of moisture removal must usually be controlled with accuracy during intermediate stages of the process, and at the end of the process of drying the material must have a very definite moisture content. This is true particularly in the manufacture of various tobacco products, artificial silk, certain gelatine products including photographic films, lumber, paper and macaroni. The importance of exact control of moisture in the finished product is notable in artificial silk, which is manufactured annually to the value of hundreds of millions of dollars. A variation of but one per cent in the moisture content of this silk would mean a very wide range in the sale price of the product. Although such variation in moisture might not affect the intrinsic value of the silk a regulated moisture content definitely is preferred by the purchasers. The same is true to a less extent with cotton yarns, where an increased moisture content is desirable not only from the sales standpoint but also from the manufacturing standpoint.

Wheat flour is another product which requires careful moisture standardization; and considerable attention is being given to this field at the present time.

Air conditioning is important in certain branches of the chemical industry in controlling the temperature of reaction and in facilitating or retarding evaporation.

The control of the moisture content of air supplied to blast furnaces in the manufacture of pig iron is advantageous, and with present improved methods of moisture removal from the air, this field may become prominent.

AIR CONDITIONING FOR EFFICIENCY OF EMPLOYEES

Air conditioning combined with ventilation is commercially desirable from the standpoint of efficiency of employees. In many industries the output is affected, and in some cases the output is limited, by the physical endurance of the workers. The output of a factory, therefore, is greatly increased by the proper control of temperature and humidity conditions, if these conditions are normally unfavorable without control. This is particularly true in the cotton mill industry, in steel rolling mills, in hot climates such as that of India, in deep mines, particularly in Brazil, India and South Africa, and in the manufacture of glazed iron ware and similar processes.

In some industries, such as the lithographic industry, the quality of the product and the personal comfort of the employees assume almost equal importance. In order that the proper register may be obtained for the application of the different colors which may be applied, one at a time on different days, a very exact humidity control is necessary, and in hot, moist weather perfect registry can be secured only by dehumidification and by artificial refrigeration, or, if employees comfort is to be ignored, by heating to such a degree as to be almost unbearable for human beings.

In other industries, the product is affected both by relative humidity and temperature, as in the manufacture of chocolates, chewing gum, cigarettes and machine-made cigars. In these industries it is necessary to humidify during some parts of the year, and to dehumidify and refrigerate at other seasons, in order to maintain a uniform condition within the limits permissible by the product.

In many instances, of course, the atmospheric conditions best suited to the products and process are ideal for the health, comfort and efficiency of the workers.

AIR CONDITIONING FOR HUMAN COMFORT

Air conditioning systems are being used more extensively for controlling conditions for personal comfort. Buildings in which air conditioning is used for this purpose include auditoriums, theaters, department stores, hotels, restaurants, banks and office buildings.

Ventilation with cooling and dehumidification have been proved to offer high economic returns for buildings in which human comfort is the sole objective.

In large department stores air conditioning with refrigeration has been found to be a very satisfactory method of securing the desired degree of comfort during days of special summer sales, when large numbers of people are present. The investment for refrigerating equipment of such installations often represents approximately one third of the cost of the entire installation.

Large air cooling installations cost nearly $200 per ton of refrigeration to install for the refrigerating equipment alone, yet it is evident that the investment is economically sound, from the rapidly increasing number of installations which are being made.

FUNDAMENTAL PRINCIPLES

The art of air conditioning is based upon very definite physical principles. The phenomena involved have been given intensive study, both from the theoretical and experimental standpoint. As a result, the various relationships have been quantitatively expressed, either rationally or empirically.

The usual requirement in air conditioning as applied to processing hygroscopic materials is to maintain a definite moisture content of the product. In some cases, however, it is desired to control merely a definite moisture content of the air. In problems involving human comfort, it is necessary to maintain certain limiting or desirable effective temperatures which depends upon the experimentally-determined relationships of wet and dry bulb temperatures and air motion.

It should be noted that the moisture content in a given space is independent of the maximum quantity of air or other gases present. In other words, the properties of saturated water vapor are assumed to be in no way affected by the presence of other gases. The quantity of moisture present in a given space may then be determined directly from the data available involving the physical properties of water vapor.

As is well known, the vapor pressure of water, and consequently the weight per unit of volume of that vapor, depends upon its temperature. Vapor pressure and density curves and tables are available for all the ranges of atmospheric temperature, and the accuracy of these generally can be relied upon.

Where the vapor pressure of the water vapor present is known, it is evident that the proportionate weight of water vapor to other gases in the mixture obeys Dalton's law; assuming, of course, that the gases have no chemical affinity. This may be expressed by the relationship:

$$W = \frac{Se}{P-e} \tag{1}$$

where

W = weight of moisture per pound of air.
S = specific weight of water vapor compared with air as 1.
P = barometric pressure.
e = vapor pressure at temperature t.

If other gases than air are present, then the specific weight of water vapor must be taken as the density of the water vapor with reference to the density of the gas at the same pressure and temperature.

The theoretical specific weight of steam, assuming that it obeys the gas laws, would be the ratio of the molecular weight of steam to that of pure dry air. At low temperatures the actual specific weight approaches very closely this theoretical, while at high temperatures the deviation is considerable. The curve of actual specific weights of water vapor is given in Fig. 1.

From this, it is possible to compute with accuracy the weight of water vapor contained in a pound of dry air at any given vapor pressure and barometric pressure.

In a mixture of air and water vapor, a point is reached where there is a maximum quantity of water vapor present for any temperature; that is, the air is saturated when the vapor pressure corresponds to the temperature.

Air, however, is usually deficient in water vapor. That is, it is unsaturated, in which case the vapor pressure is lower than the maximum corresponding to the temperature of the mixture. The ratio of such vapor pressure to the vapor pressure of the mixture when saturated at that temperature is termed the *relative humidity*. That is:

$$\text{Per cent relative humidity} = \frac{e}{e_t}$$

$$\text{Per cent relative humidity} = \frac{D}{D_t} \text{ (approximately)} \qquad (2)$$

where e and D are the pressure and the density respectively of the vapor in the air, and e_t and D_t are the saturation pressure and density respectively of the vapor corresponding to the temperature t of the mixture.

Dew-Point

If such an unsaturated mixture of air and water vapor be cooled, without the removal of any moisture present, it will ultimately become saturated. This temperature is termed the *dew-point*, for any further cooling will result in a deposition of moisture from the mixture.

Temperature of Evaporation

In the instance cited, the air was saturated by withdrawal of heat and without change in the moisture content.

Air may also be saturated adiabatically by being brought into contact with the liquid itself without any addition or subtraction of external energy. Under this condition water vaporizes into the space occupied by the air, assuming that no heat is available from the water itself. That is, no temperature change takes place in the water present, and the heat required for change of state must come from the sensible heat in the air itself, thus resulting in the lowering of its temperature.

The moisture content of the air, therefore, is increased and its temperature is lowered simultaneously, and it is obvious that the increase in latent heat must exactly equal the decrease in the sensible heat of the mixture. Further, this process will go on until the air becomes saturated, when no further exchange between the sensible and latent heat is possible. This final temperature at which adiabatic saturation takes place in any body of air of known temperature and moisture content is known as the *temperature of evaporation* and corresponds to the *wet-bulb* temperature.

In order that no heat exchange may take place between the water and the surrounding air, it is necessary that the water shall be introduced at the temperature of evaporation. On the other hand, if free water shall be exposed to a continuous current of air of a given temperature and moisture content, the water will ultimately assume of its own accord this equilibrium temperature of evaporation. This is not only logical, but has been proved experimentally. It is for this reason that an ordinary thermometer which has its bulb covered by a wetted cloth or otherwise is coated with the liquid, if protected against outside sources of heat such as radiation and if subjected to a stream of air having a definite temperature and moisture content, will indicate the temperature of adiabatic saturation. This proves the identity between what is termed the *wet-bulb temperature* and the *temperature of adiabatic saturation*.

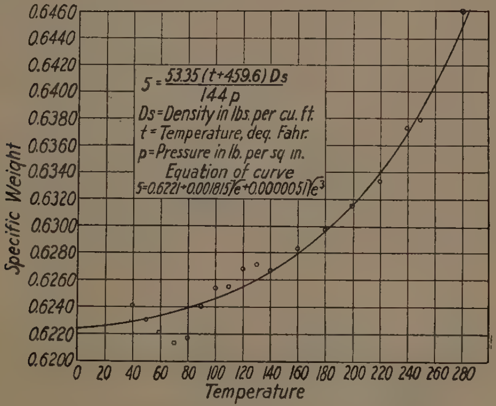


FIG. 1. SPECIFIC WEIGHT OF WATER VAPOR

With the ordinary sling psychrometer which is used in measuring the moisture content of air, however, there is always some radiation present and, if the wet-bulb be not strongly ventilated, the error due to radiation may be considerable. With strong ventilation, however, the radiation effect is usually less than one per cent. This error depends upon the temperature and velocity of air movement, and the relationship of this error to these factors is shown in a paper entitled *The Temperatures of Evaporation of Water into Air*, presented by W. H. Carrier and D. C. Lindsay, before the *American Society of Mechanical Engineers* in 1924.

From the foregoing, the following fundamental principles in air conditioning may be evolved:

1. When dry air is saturated adiabatically the temperature is reduced as the absolute humidity is increased, and the decrease of sensible heat is exactly equal to the simultaneous increase in latent heat due to evaporation.
2. As the moisture content of air is increased adiabatically, the temperature is reduced simultaneously until the air is saturated, when no further heat metamorphosis is possible. This ultimate temperature may be termed the temperature of adiabatic saturation.
3. When an insulated body of water is permitted to evaporate freely in the air, it assumes the temperature of adiabatic saturation of that air and is unaffected by convection, *i.e.*, the true wet-bulb temperature of air is identical with its temperature of adiabatic saturation.
4. The true wet-bulb temperature of the air depends entirely on the total of the sensible and the latent heat in the air and is independent of their relative proportions. In other words, the wet-bulb temperature of the air is constant, providing the total heat of the air is constant.

It will be obvious in considering the foregoing process, that a formula relating the latent heat change to the sensible heat change establishes the relationship of this theoretical wet-bulb temperature to the temperature and moisture of the air. This was first pointed out by W. H. Carrier in the Rational Psychrometric Formula:

$$r^{\prime} (W^{\prime} - W) = C_{\mathrm{pa}} (t - t^{\prime}) + C_{\mathrm{ps}} W (t - t^{\prime}) \qquad (3)$$

in which

$(t - t^{\prime})$ = the true wet-bulb depression.
$(W^{\prime} - W)$ = the moisture absorbed per pound of pure air when it is adiabatically saturated from an initial dry-bulb temperature t_0 and an initial moisture content W.
C_{pa} = mean specific heat of air at constant pressure between temperature t and $t^{\prime}$.
C_{ps} = specific heat of steam at constant pressure between t and $t^{\prime}$.
$r^{\prime}$ = latent heat of evaporation at wet-bulb temperature $t^{\prime}$.

Knowing any two of the three important values of t, $t^{\prime}$ or W, the third may be solved.

This is an exceedingly useful relationship, not only in air conditioning and the drying of materials but in the psychrometry of air or other gases to which it directly applies. It is evident that if the wet-bulb temperature of air of a known dry-bulb temperature but unknown moisture content be determined experimentally with the wet-bulb thermometer, it will be possible to calculate directly the moisture content of that air from the relationship.

From equation (3) a psychrometric chart in common use has been evolved. (See Figs. 1, 2, 3, 4, 5, Chapter 3, and Fig. 4, Chapter 29). This is most useful in all problems pertaining to air conditioning, drying, and in the determination of the moisture content of air.

A formula has also been derived which will permit the approximate calculation of the vapor pressure from the wet-bulb temperature observation. This is useful particularly in determining relative humidities for conditions other than the standard barometric conditions for which the chart is made. The formula for expressing this relationship is:

$$e = e' - (P - e')\ (t - t')\ 2{,}800 - 1.3t' \tag{4}$$

where

e = partial pressure of the moisture in the air, which also equals vapor pressure corresponding to the dew point.
e' = the vapor pressure corresponding to saturation at wet-bulb temperature t'.
P = the barometric pressure.
t = dry-bulb temperature in deg. fahr.
t' = wet-bulb temperature in deg. fahr.

Total Heat

In cooling and dehumidifying air, it is necessary to take into consideration not only the sensible heat of the air itself but the latent heat of the moisture removed.

Air at any temperature and moisture content may be considered as having a certain definite total heat in thermal units per unit weight as calculated from some arbitrary base, such as zero moisture and zero temperature. By using the psychrometric chart, on which are given wet-bulb temperatures and corresponding total heats, it is possible to determine the total heat to be removed in the process of dehumidification by subtracting the total heat of the cooled air with its reduced moisture content from that of the air in its initial condition as indicated on the chart.

This process is simplified greatly by taking into account the fourth psychrometric principle, by observing the fact that the wet-bulb temperature of the air may be used as the measure of the total heat which the air contains. Thus, by referring to the chart, having given air of known temperature and known moisture content, a corresponding wet-bulb temperature is obtained. Then, under standard barometric conditions, the quantity desired is determined by reference to the curve of total heat. For example, air at 85½ deg. with 80 per cent relative humidity has exactly the same total heat as air at 101 deg. and 40 per cent relative humidity, because in both cases the wet-bulb temperature is 80 deg. This wet-bulb temperature represents about the maximum wet-bulb temperature ever encountered in the Temperature Zones under extreme conditions, and is nearly the maximum found in the Tropics. A normal high wet-bulb temperature for the Temperature Zone may be taken at 75 deg. in calculating requirements for air cooling, as this is seldom exceeded, except for short periods.

Relation of Dew-Point to Relative Humidity

A peculiar relationship exists between the dew-point and the relative humidity and this is found most useful in air conditioning work. This is, that for a fixed relative humidity there is substantially a constant difference between the dew-point and the dry-bulb temperature over a considerable temperature range. The following table giving the room temperature, dew-point temperature, and dew-point differentials for 50 per cent relative humidity illustrates this relationship most clearly:

Dry-bulb temperature	65.0	70.0	75.0	80.0	85.0	90.0
Dew-point temperature	45.8	50.5	55.25	59.75	64.25	68.75
Difference between dew-point and dry-bulb temperature	19.2	19.5	19.75	20.25	20.75	21.25

It will be seen from an inspection of this table that the difference between the dew-point temperature and the room temperature is approximately 20 deg. throughout this range of dry-bulb temperatures or, to be more exact, the differential increases only 10 per cent for a range of practically 25 deg.

This principle holds true for other humidities and is due to the fact that the pressure of the water vapor practically doubles for every 20 deg. through this range.

The approximate relative humidity for any difference between dew-point and dry-bulb temperature may be expressed as:

$$\frac{100}{2^{\frac{t - t_1}{20}}} \tag{5}$$

where

t_1 = dew-point temperature.

This principle is very useful in determining the available cooling effect obtainable by the use of ventilation with saturated air when a desired relative humidity is to be maintained in a room, even though there may be a wide variation in room temperature. This problem is one which applies to certain industrial conditions, such as those in cotton mills, tobacco factories, etc., where relatively high humidities are carried and where one of the principal problems is to remove the heat generated by the machinery. It also permits the use of a differential thermostat, responsive to both the room temperature and to the dew-point temperature, to control the relative humidity in the room.

Rate of Evaporation

In problems of air conditioning and drying, as well as in other industrial applications of evaporation, such as cooling towers, for example, it is desirable to determine the rate of evaporation. There are two distinct cases of evaporation. The *first* case is that in which the source of heat is primarily from the water itself and in which the air temperature may even be raised. The *second* is that in which the heat for evaporation is obtained entirely from the air itself, in which case the air is cooled and the temperature of the water remains substantially constant at the wet-bulb temperature. Both cases, however, may be reduced to a common basis of calculation. It has been found that the increase in the rate of evaporation is nearly in direct proportion to the increase in the air velocity, and that it is in direct proportion to the difference in vapor

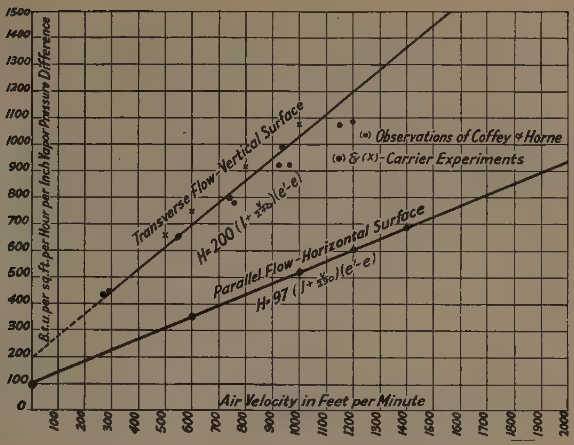


FIG. 2. HEAT TRANSMITTED BY EVAPORATION

pressure between the vapor pressure of the water and the pressure of the vapor in the air.

The general formula covering the experimental data may be expressed as follows:

$$\frac{dw}{dt} = (a + bv)\ (e' - e) \tag{6}$$

where

$\frac{dw}{dt}$ = rate of evaporation.
a = the rate of evaporation in still air.
b = the rate of increase with velocity.
e' = the vapor pressure of the liquid.
e = the vapor pressure in the atmosphere.
v = velocity.

The only difference between case *one* and case *two* is that in case *one* the vapor pressure of the liquid is one of the known or assumed factors, being dependent upon the known temperature of the liquid, while in case *two*, e' is the vapor pressure corresponding to the wet-bulb temperature of the air.

This wet-bulb or evaporation temperature is dependent upon the dry-bulb temperature and the moisture content, or upon the total heat of the air as indicated in the previous paragraph.

The effect of air velocity depends upon whether the flow of air is parallel to the surface or perpendicular to the surface elements. For a flow of air *parallel* to a horizontal surface

$$w = 0.093\left(1 - \frac{v}{230}\right)(e' - e) \quad \text{(approximately)} \tag{7}$$

where

w = pounds evaporated per square foot per hour.
v = velocity of atmosphere over surfaces in feet per minute.
e' = vapor pressure of the water corresponding to its temperature.
e = vapor pressure in the surrounding atmosphere.

For *transverse* flow, as across a tubular surface, the rate of evaporation is nearly doubled.

These relationships are indicated graphically on the chart, Fig. 2.

Since the difference in vapor pressures is substantially proportional to the difference between the wet and dry-bulb temperatures (*i.e.*, the wet-bulb depression) the rate of evaporation is also for case *two* substantially proportionate to the wet-bulb depression.

In case *two*, the rate of sensible heat transfer, from the air to the liquid to produce evaporation is substantially the same as the rate of heat transfer with the same type of surface, without moisture being present, but with the same temperature differences. In other words, the rate of heat transfer depends upon the temperature difference only, whether the surface is wet or not. For example, it has been shown that the rate of heat transfer with air flowing across staggered coils (transverse flow) may be represented by the formula:

$$U_t = \frac{1}{0.0447 + \frac{50.66}{v}} \tag{8}$$

where

U_t = heat transfer expressed in B.t.u per hour per square foot per degree difference in temperature between steam and air, for transverse flow.

At a velocity of 400 ft. per minute, $U_t = 5.8$, and at a velocity of 800 ft. per minute, $U_t = 9.3$.

Referring to Fig. 1, showing the rate of heat transmission by evaporation for different air velocities, it will be noted that for transverse flow there are 560 B.t.u. per hour per square foot transferred per inch difference of vapor pressure at a velocity of 400 ft. per minute and 910 B.t.u. per hour per square foot per inch difference in vapor pressure at a velocity of 800 ft. per minute. One inch of vapor pressure difference corresponds approximately to 95 deg. difference between the wet and dry bulb temperature. Dividing by 95, the value of 5.9 B.t.u. per square foot per degree difference in temperature is obtained for a velocity of 400 ft. per minute and 9.55 B.t.u. per square foot for a velocity of 800 ft. per minute.

It will be noted that for these two cases the heat transfer by evaporation per degree difference in temperature corresponds almost exactly with the heat transfer by convection coils. The similarity may be noted by comparing the formula for heat transfer in parallel flow where with

$$U_p = \frac{1}{0.026 + \frac{161}{v}} \tag{9}$$

the heat transfer by evaporation with parallel flow. The relationship will be seen to be very close in both cases and would indicate that the heat transfer by evaporation is actually brought about by a process of convection.

The difference in form of the two formulae may be due in part to errors in observation at the higher and lower velocities.

In cooling air and condensing out the moisture therefrom the heat transfer is considerably more rapid than when the air is dry and no moisture is condensed. In general the rate of heat transmission on the air side is increased an amount which is proportionate to the latent heat removed as compared with the sensible heat removed. That is, if the latent heat removed was 50 per cent of the sensible heat removed, then the conductivity of the surface in contact with the air would be increased approximately 50 per cent.

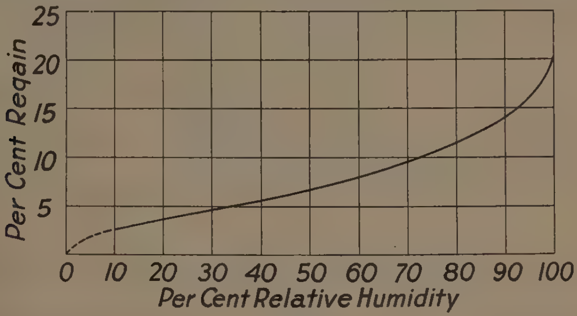


FIG. 3. REGAIN CHART FOR COTTON (SEA ISLAND) AND PAPER (CELLULOSE) AT 70 DEG.

Hygroscopic Properties of Materials

Hygroscopic materials are those which readily absorb or give off moisture to the surrounding air.

Air conditioning in many industries is largely concerned with the control of this hygroscopic moisture. The moisture content of a hygroscopic material when in equilibrium depends upon the relative humidity of the surrounding air, but varies widely for different materials.

The moisture content also varies to some extent for different temperatures at the same relative humidity. The content of hygroscopic moisture is sometimes termed *regain* and is expressed in parts of water per 100 parts of dry material. The curve (Fig. 3) shows the effect of moisture content upon the rate of drying of cotton and paper, with an air temperature of 70 deg. fahr. dry-bulb.

If the material contains moisture in excess of the *regain* corresponding to any relative humidity, then it will give up moisture to the air with the absorption of heat and there will be a resultant cooling effect equal to that of evaporation. On the other hand, if the hygroscopic material contains moisture below that of the corresponding atmosphere, it will absorb moisture from the air with a release of heat which corresponds to the latent heat given off if a corresponding quantity of water vapor were condensed.

Certain chemicals, such as a concentrated solution of calcium chloride, solutions of sulphuric acid, alcohol, etc., are correspondingly hygroscopic and react to changes in moisture in the same way. In certain cases, however, such as with sulphuric acid, there is not only the latent heat of absorption but also a chemical heat of combination.

AIR CONDITIONING EQUIPMENT

Air conditioning equipment comprises:

1. Apparatus for providing the necessary heat and moisture exchanges within the room to be conditioned and of the air supplied to the room for ventilation.
2. Automatic devices for governing such apparatus so that temperature and humidity may be controlled within the limits desired. The latter are referred to as controls. Those for controlling temperature are known as thermostats, and those for controlling humidity are known variously as hygrostats, psychrostats, or humidostats.

Apparatus for effecting humidity changes may be divided into two distinct groups:

1. The humidifiers used for the purpose of increasing the moisture content of the air and to produce cooling by evaporation.
2. The dehumidifiers used for the removal of moisture from the air and to produce cooling by contact with water or surfaces at a lower temperature than the air.

Systems of Humidification

Humidifiers may be divided into the following general types, according to the method of operation:

1. *Indirect:* Introduction of moistened air.
2. *Direct:* Spraying into the room.
3. *Combined:* Direct and indirect.

Before the advent of modern air conditioning the direct humidifiers were largely used for increasing the humidity in cotton mills and similar places. There has been much improvement in this type of humidifier and it still finds wide application, especially in the textile mill industry.

One of these types uses atomizer heads in which the water is drawn into the nozzle and then finally atomized by a small jet of air under high pressure. This type is illustrated in Fig. 4.

In another type, water is supplied at high pressure (usually about 200 lb. per square inch) to an atomizing nozzle. This nozzle is located in a sheet metal enclosure, suspended from the ceiling, through which a current of air is caused to pass, either by the action of a motor-driven disc fan or by the induction action of the spray itself. The heavier particles of water are separated by a simple method of baffling and only the very finest particles are caused to pass into the room, with the current of air, where they are rapidly evaporated. This type is illustrated in Fig. 5.

In a third type of direct humidifying head a small jet of water is thrown upon a disc rotating at high velocity within a stationary circular comb which consists of fine metal strips or teeth, against which the water thrown from the disc impinges. The finely atomized particles of water are carried out with the current of air created by a disc fan operated from the motor shaft. This type is illustrated in Fig. 6.

The three types of direct humidifiers described are suitable only for application in certain types of industrial plants and do not provide either for controlled ventilation or for dehumidification. These two provisions are essential in many industries and for installations providing for human comfort.

Indirect humidifiers are similar in operation to spray-type air washers, except that the water is sprayed directly against the current of incoming air. Such humidifiers comprise a chamber usually 10 ft. or more in length, through which the air is drawn at a velocity from 500 to 700 ft. per minute. Inside the chamber are placed one or more banks of spray nozzles distributed uniformly over the cross-sectional area of the chamber. These nozzles create a finely divided spray through centrifugal action and require water pressures for effective humidification of from 35 to 45 lb. per square inch. At the intake of the humidifying chamber there is provided a set of baffles for distribution of the air and for preventing the spray from escaping from the chamber. At the outlet of the humidifier chamber there is provided an eliminator. This eliminator, consisting of a series of metal baffles, is so designed as to separate all of the free, unevaporated moisture from the humidified air. Thus the air leaving the humidifier is completely saturated, but without any entrainment or unevaporated water particles. The general construction of this type of humidifier is shown in Fig. 7. Such humidifiers are used only in connection with ventilating systems. They are practically always placed on the inlet side of the ventilating fan. Provision is made for warming the water in winter so that the air may be saturated at a definite temperature.

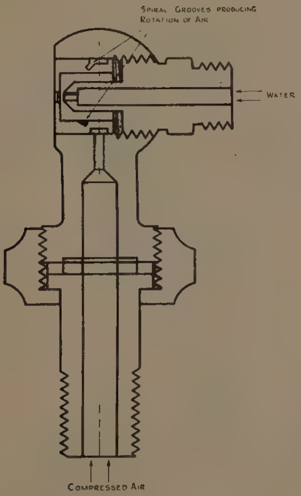


FIG. 4. DIRECT TYPE HUMIDIFIER HEAD

The heating of the water usually is controlled by means of a thermostat placed in the path of the saturated air leaving the humidifier and controlling the heater through which the spray water passes.

In other cases, particularly in industrial work where high humidities are maintained, the control of the dew-point temperature is effected by a thermostat controlling the mixture of outside air and return air from the building by means of fresh and return air dampers at the inlet of the humidifier.

In industrial work the dew-point regulation is effected in winter time by both of these means operating in conjunction. In those installations where all outside air must be employed, it is usual to provide in front of the air washer certain pre-heater coils of sufficient capacity to bring the air to a temperature slightly above the freezing point. In summer time operation, whenever the outside wet-bulb temperature is above the minimum dew-point desired in the building, all outside air supply is taken and it will be observed from the psychrometric principles previously discussed that the air issuing from the humidifier will have been cooled to the wet-bulb temperature of the entering air, provided, of course, that the water is neither heated nor cooled by recirculation, which is usually the case in such installations.

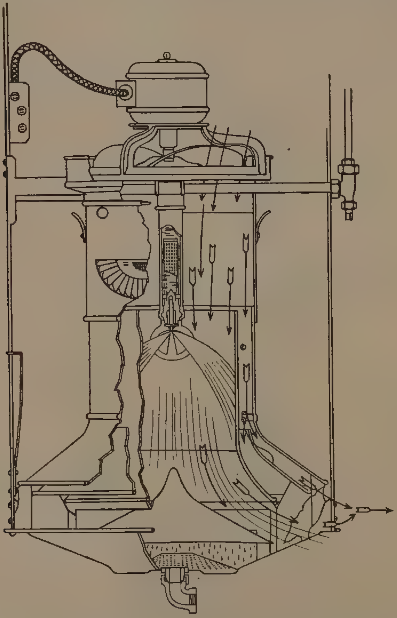


Fig. 5. Another Type of Humidifier Head

In most manufacturing processes relatively little moisture is added to, or extracted from, the air in the room by the process itself, and as windows and doors are closed, conditions in the room rapidly stabilize to the moisture content of the entering air. Thus, it is possible to control the relative humidity within the room by proportioning the quantity of the air in accordance with the heat sources within the room, such as heat from machinery and the occupants, electric lights, sunlight and outside radiation. The quantity of air to be supplied for each unit of heat thus removed is definitely dependent upon the relative humidity to be carried.

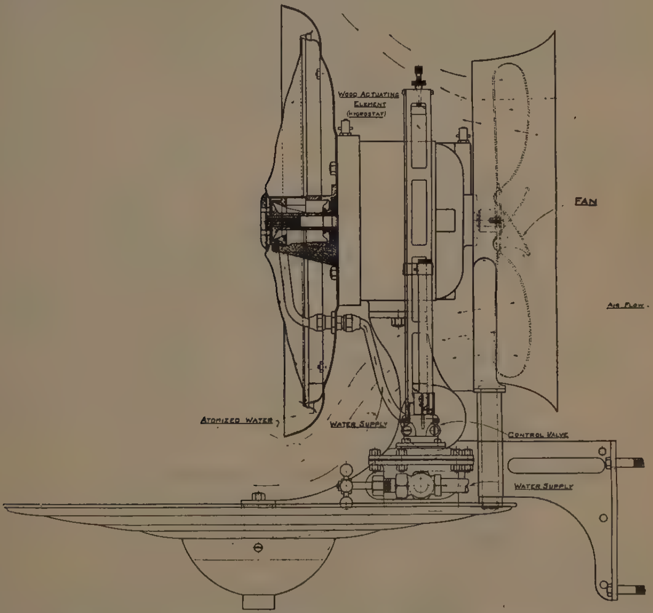


FIG. 6. TYPE OF HUMIDIFIER IN WHICH A SMALL JET OF WATER IS THROWN ON A ROTATING DISC

For example, if 50 per cent relative humidity is to be carried in the room the ventilation must be restricted so there shall be a rise of 20 deg. between the temperature of the entering air and that of the air in the room itself. Smaller temperature rises would give increased relative humidities. In textile mills, for instance, with the humidities usually carried it is possible to keep the room temperature within about 12 deg. of the outside wet-bulb temperature. Inasmuch as the wet-bulb temperature on hot days is usually 15 deg. to 25 deg. lower than the dry-bulb temperature, the mill temperature will be below the outside temperature and provision has to be made by inward transfer of heat through the walls for the heat thus absorbed. The general design of such a system of humidification and air conditioning is shown in Fig. 8.

Dew-point control is particularly applicable where there are a number of different departments to be served from one central equipment, and where there is but little change in the moisture content of the air in the room due to moisture changes in the materials processed or due to excessive air leakage from outside.

Another system of control which is used considerably, especially where there is but one room to be controlled from one apparatus and where there may be considerable moisture change in the room itself due to local conditions, is to adjust the dew point at the apparatus, either continuously or intermittently, by means of a hygrostat placed in the room and so connected as to vary either the temperature or quantity of spray water used in the humidifier, or both. This system may be designated as *direct relative humidity control.*

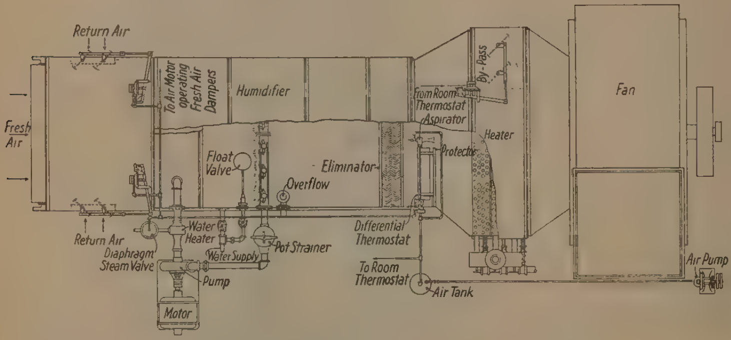


FIG. 7. PLAN OF HUMIDIFIER WITH HUMIDITY CONTROL

In direct humidity control installations the temperature and humidity are both under control during the heating season, and in the summer the humidity must be maintained constant, but the temperature must be allowed to rise in accordance with the increase of the wet-bulb temperature above the minimum desired. Temperature variations under mill conditions will be from 75 deg. to 90 deg. fahr. Such results are superior from the standpoint of comfort and well-being of the operators than those previously experienced without the control. Automatic humidity control has resulted greatly in increasing the effectiveness of the workers, but the provision of ventilation also has improved greatly the conditions in mills as to dust, lint, and odors. In the spinning of fine cotton yarns, automatic humidity control is of great value in producing an improved product as well as in bettering working conditions. The uniform air motion results in the lowering of the effective temperature with a consequent increase in comfort and efficiency of the workers at temperatures and humidities which are necessarily high because of the requirements of the product. The air motion results also in removing the heat directly and immediately from the point of production on the spinning frame, thus avoiding localized increase of temperature and decrease of relative humidity. In other words, it permits the entire process to be subjected more nearly to the average room conditions.

Where large quantities of power are generated in a limited space and where a comparatively high relative humidity is required, it is often feasible and economical to use a combination of direct and indirect humidification. The indirect humidification provides the desired quantity of ventilation and cooling and the additional direct humidification provides for increase in humidity without interfering with the ventilation or the cooling effected by the indirect system.

In general, it may be stated that direct humidification is most satisfactory where high humidities are desired but where little cooling, ventilation or air motion is required. Therefore, the indirect system is most applicable where either low or high relative humidities are desired with maximum cooling and ventilation effect. For conditions that require an unusually large amount of heat to be absorbed by ventilation, together with the maintenance of high humidities, it is ofttimes preferable to make use of the combination system of indirect and direct humidification. If the indirect system alone were used it would mean an unusually large volume of air to be handled, which might interfere, due to air motion, with production, even though it would result in greater cooling effect. If direct humidification alone were used, no ventilation would be obtained, with consequently higher room temperatures.

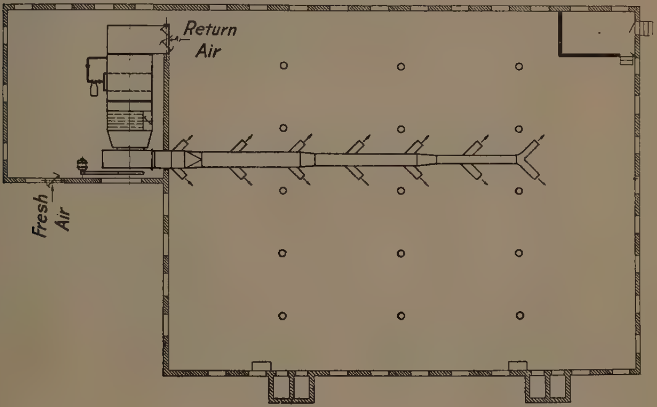


FIG. 8. GENERAL DESIGN OF A SYSTEM OF HUMIDIFICATION AND AIR CONDITIONING

Inasmuch as cooling and humidification requirements in summer are much more severe than those in winter, an excess of humidifying and cooling capacity must be provided to meet extreme conditions and this requires automatic control if the best results are to be obtained. Such applications of humidity control may be considered standard practice today in the United States.

The same type of equipment as used in cotton mills largely is applicable to other textile industries, including rayon manufacture and also is applicable to tobacco factories, paper mills and many other buildings.

Systems of Dehumidification

In many industries it is as important to control the temperature in summer as in winter and, at the same time, the relative humidity must be controlled both in summer and in winter. To accomplish this the air must be warmed and the humidity must be increased in winter, and the air must be cooled and the moisture content of the air must be reduced in summer, so that both temperature and humidity indoors may be held at a definite point regardless of outside weather conditions, and regardless of conditions within the plant itself.

The design of air distribution equipment and the external appearance of such equipment is the same as described for systems of humidification. The main differences are found in the internal construction of the dehumidifier, in the use of refrigeration or of heat as required for controlling the water temperature, and in differences in the general methods of control.

Dehumidifiers are of two general types. *First*, the spray type in which the water is cooled outside of the spray chamber and then introduced. *Second*, the type in which the refrigerating coils are placed directly in the spray chamber and in which the water is sprayed over this surface, air coming in contact both with the wetted coils and the spray.

The use of refrigerated surfaces for cooling and dehumidifying air has given way almost entirely to the use of the direct spray of cooled water. One of the principal reasons for this change is the high effectiveness of heat transfer between the finely divided spray and the air, which is thereby lowered substantially to the temperature of the leaving water. This efficient heat transfer reduces greatly the temperature head required in refrigeration, and therefore, reduces the size and cost of the refrigerating equipment.

With the spray type of dehumidifier, all the water vapor is condensed from the air to the point of saturation at the temperature corresponding to that of the air leaving the dehumidifier and all free moisture is removed by a series of baffles or eliminators, in the same manner as in the standard air washer. The spraying of water into the air to remove moisture from it might seem paradoxical, except for the application thereto of easily understood laws of physics.

Both types of dehumidifiers have air-distributing baffles at the inlet end and eliminators at the outlet end. The dehumidifier usually is considerably longer than the humidifier and in the spray type there are two or more sets of sprays, some of which may be directed against the air flow.

The object is to obtain a coarser spray and, at the same time, a much larger quantity of cold water per unit of air to be treated, than in the humidifier. Heat absorbing capacity as well as surface must be provided in the spray water. The usual allowable rise in spray water temperature entering and leaving the dehumidifier is from 6 deg. to 10 deg. fahr., and in well-designed dehumidifiers of the spray type the final temperature of the air is substantially identical with the final temperature of the leaving water. This is made possible by the counter-flow effect employed in such apparatus. The air velocities through the dehumidifier usually are lower than those employed in the humidifier, normal velocities being from 400 to 550 ft. per minute through the cross-sectional area.

Greater care must also be taken to obtain the elimination of free water than with the humidifier, as an entrainment beyond the eliminator defeats the purpose of the equipment.

Dehumidifier systems usually are provided with two essential control elements; a dew-point control at the apparatus and a room control. The former maintains a uniform temperature of saturated air leaving the dehumidifier at all times of the year. In summer, in industrial work, this is so constructed as to use nearly all return air, thus reducing the refrigerating load required, while when the wet-bulb temperature outside is below the dew point required within the room the latter is controlled by the dew-point thermostat which brings about a mixture of fresh and return air as required. The room temperature is controlled independently at a definite point above the dew-point or saturation temperature either by a thermostat or by a hygrostat, depending upon whether the more important factor is the temperature or the relative humidity. Frequently the nature of the process is the governing factor in the selection of control. For example, if moisture is given off or taken up by the materials in the process of manufacture, and if the relative humidity is the more important factor, then the hygrostat would be used. The amount of infiltration, which affects both temperature and humidity, may also be the governing factor in the selection of control, and the instrument selected would depend on whether the control of temperature or humidity is the more important. The control operates either with volume dampers controlling the quantity of air introduced, or with valves or dampers which govern the heat output from local heaters such as radiators. Usually the control is a combination of both volume control and of air temperature control.

In installations for auditoriums and theaters the requirements are different from those in factories, since there must be a considerable volume of air circulated in order to provide ventilation and cooling. The moisture content of this air must be relatively constant, but its temperature must be variable. A satisfactory solution of this problem has proved difficult, but special systems of control are now in general use which permit the temperature and humidity of theaters to be controlled independently and at the same time, to be immediately responsive to changes in occupancy. Some of these arrangements are successful in operation without the use of any external heat whatever.

SYSTEMS OF AIR DISTRIBUTION

In systems of air conditioning, the method of air distribution, as well as the practical details of design are of utmost importance.

In an installation where exact relative humidity control is required, uniform temperature conditions are very important, because a variation in relative humidity will be caused by any variation in temperature.

Moreover, the air is usually admitted, especially in summer, at temperatures lower than that of the room in order to effect the necessary cooling. Therefore, the air must be distributed uniformly, not with respect to floor space but with respect to the amount of heat to be absorbed in the various portions of the room. Thus it is necessary for the air conditioning engineer to have fairly exact information as to the distribution and sources of heat within the room, or else to have means of controlling the temperature or quantity of air supplied to the different sections independently. A great deal of attention has been given to various methods of air distribution. In industrial work there have been developed adjustable diffusers which will spread the air uniformly in a fan shaped manner. Such outlet may be provided also with dampers which will permit any desired reduction of velocity without changing the uniformity of distribution.

A second system of distribution utilizes a series of nozzles near the ceiling, discharging horizontally at high velocity from one side of the room toward the other. The size of the nozzles used and their spacing governs the distance to which the air may be carried. Such a system depends for its effect, primarily, upon the ejector action of a high velocity current of air. This induces a positive movement in a parallel direction of the surrounding air and this in turn produces a secondary current in the opposite direction over the entire floor area to be conditioned. The volume of the secondary air current when set into motion is usually several times that of the primary air discharged, the ratio depending upon the velocity of the air leaving the nozzles. This system is known as the ejector system of air distribution and is particularly effective in securing a thorough mixture of the air in the room and a corresponding uniformity of temperature and humidity. The ejector system has been applied largely and is used in the cooling and air conditioning of auditoriums, but can be applied to industrial problems, especially those involving the drying and processing of materials.

A third system of distribution aims at producing the required results with overhead outlets. This system is known as the pan system of air distribution. In this system the air is distributed entirely from overhead, symmetrical distribution, arranged to serve all areas being desirable. The air is discharged downward against a flat plate and is thus diffused radially in all directions, laying a blanket of cool air which mixes with the warmer air already in the room as it descends. The pan system of distribution has found favor in installations for auditorium cooling, as it is a most effective way to avoid drafts. It is also very useful in certain industrial applications where cooling is required and where it is desired not to have high velocities of air or sudden temperature changes.

A fourth method which was at one time largely used is the upward system. The air is delivered through mushroom hoods in the floor. In theater cooling and air conditioning, however, this upward delivery has objections unless very low velocities are used and unless all seats are occupied. Owing to complaint by occupants from drafts, and because of great variations in temperature between floors and upper levels its use is not general today.

HUMIDITY CONTROLLING DEVICES

Hygrostats are of two general types.

One type is a differential thermostat, in which one expansive element is affected by the wet-bulb temperature, which temperature is suitably maintained either by a wick or a spray of water, while another expansive element is normal to the room. These thermostatic elements are so interconnected that they will not be affected by changes of temperature alone, but will be affected only by changes in the relation between the wet and dry-bulb temperatures, which would result in changing the relative humidity. Such a correlation is made possible by the fact that there is practically a straight-line relationship between the relative temperature changes of wet and dry bulb for any definite relative humidity. As in the thermostat, these elements may be either of the solid expansion or of the vapor pressure type.

A second form of hygrostat depends upon the dimensional changes of hygroscopic materials due to changes in moisture content. In these instruments the humidity responsive element works directly upon pneumatic valves or electric contacts. The sensitive element expands or contracts in response to relative humidity changes and thereupon influences the actuating mechanism precisely as the thermostat responds to temperature changes.

It is found that suitable hygroscopic substances show no material change in physical size with changes of temperature, so long as the relative humidity is constant, although the actual moisture content of the hygroscopic material itself may undergo slight changes under these conditions. Certain types of these hygrostats have been made most sensitive and reliable.

Temperature and humidity controlling devices usually act upon the control valves or dampers in the air-conditioning apparatus through the medium of compressed air or electricity. For larger installations pneumatic control practically is universal in use on account of simplicity and reliability; and also on account of the fact that it permits delicate graduation of the movement of the dampers or valves in proportion to the temperature or humidity changes.

In smaller humidifying devices electric controls are very serviceable and reliable. Electricity has an advantage, because with it there are no auxiliaries, such as air compressors, air tanks, air filters, relief valves, etc., required. In the larger systems such accessories are warranted by the greater size of equipment and by the increased number of controls operated from the same compressed air source.

In the unit types of equipment, direct acting thermostats and hygrostats are sometimes used, in which the responsive element works directly upon the valves controlled, without the intermediary use of either compressed air or electric current.

UNIT AIR CONDITIONERS

For data on unit air conditioners, see Chapter 9, Unit Heaters and Air Conditioners.

REFERENCES

Rational Psychrometric Formula, By W. H. Carrier (*Transactions, A. S. M. E.*, Vol. 33, 1911).

Air Conditioning Apparatus, By W. H. Carrier and F. L. Busey (*Transactions, A. S. M. E.*, Vol. 33, 1911).

The Theory of Atmospheric Evaporation with Special Reference to Compartment Dryers, By W. H. Carrier (*Journal of Industrial and Engineering Chemistry*, Vol. 13, No. 5, May, 1921).

Coffey and Horne (*American Society of Refrigerating Engineers*, 1916).

The Temperature of Evaporation, By W. H. Carrier (TRANSACTIONS, A. S. H. V. E., 1918).

The Control of Humidity and Temperature as Applied to Manufacturing Processes and Human Comfort, By W. H. Carrier (*Heating, Piping & Air Conditioning*, November, 1929).

CHAPTER 8

AIR CLEANERS

Types of Air Washers; Temperature and Humidity Control and Steam Requirements Thereof; Viscous, Unit Viscous, Automatic Viscous and Dry Air Filters; Dust Removal Efficiency; Air Cleaner Testing Code.

EFFICIENT air cleaning devices are essential to good ventilation. The selection of such equipment is governed to a large extent by the character and amount of impurities to be removed. The most objectionable impurities in the air are soot, flue dust and carbon and its related elements. These may be classified as dusts, fumes and smokes.

Dusts are particles which are large and heavy enough to fall with increasing rapidity due to gravity in still air. For instance, particles of flying sand or grit, such as are blown about on a windy day, the average diameter of which would be approximately 0.01 cm, are called dust.

Fumes are smaller particles which fall with constant velocity due to gravity in still air. The solid particles from atmospheric fog, for instance, are called fumes and have an average diameter of about 0.0014 cm.

Smokes are particles which do not settle at all in still air, which diffuse constantly, and which are actuated by the Brownonian motion, rather than by gravity. An example of this type would be certain smokes, the average diameter of the particles of which is about 0.0000015 cm.

RATING OF AIR CLEANERS

Air washers and filters are rated as follows:

1. Capacity in cubic feet of air handled per minute.
2. Resistance in inches of water which the cleaner offers to the flow of air at its rated capacity.
3. Percentage of dust removal at its rated capacity.
4. Percentage of entrained moisture remaining in the air after passing through the cleaner while operated at its rated capacity.
5. If considered as a humidifying agent, the humidifying and dehumidifying efficiency.

The first attempt at air cleaning for general ventilation work was probably by the use of dry screens. Since ordinary Portland cement passes a screen having 100 mesh to the inch, it is apparent that much dust may pass the finest mesh screen. When a screen as fine as this is moistened, not only the dirt ceases to pass but also the air passages clog so that the filter becomes ineffective. Fine cloth filters are very effective, except that they also clog rapidly and soon become impervious to air. These considerations led many years ago to the development of the air washer types of air cleaners which use water.

AIR WASHERS

Types of Air Washers

Air washers are arranged to bring the air into contact with a large water area: (1) by passing it through a fine spray; (2) by passing it over wet surfaces; (3) by passing it both through a spray and over wet surfaces. After the air is washed it is freed from entrained water.

The moisture content of air usually is changed when it is cleansed by washing. In passing through the water spray or over the wet surfaces, both the dry and wet bulb temperatures of the air approach that of the water at which temperature the air tends to become saturated. The moisture content of the air may, therefore, be controlled by controlling the water temperature. By using water at a temperature below the dew-point temperature of the entering air, the washer becomes a dehumidifier; or by heating the water to a temperature above the dew point of the entering air the humidity or moisture contents of the air may be increased. By raising the dry-bulb temperature of the air after leaving the washer, its relative humidity may also be controlled.

Humidifying Efficiency

The humidifying efficiency of any air washer may be expressed as:

$$E = 1 - \frac{\text{Final wet-bulb depression}}{\text{Initial wet-bulb depression}}$$

For example: With an initial wet-bulb depression of 20 deg. and the final wet-bulb depression of 5 deg., the humidifying efficiency is:

$$E = 1 - \frac{5\text{ deg.}}{20\text{ deg.}} = 0.75$$

The usual humidifying efficiency of a good air washer is 70 per cent. The humidifying efficiency of air washers of the commonly termed humidifier type should range from 95 to 98 per cent.

Control of Temperature and Humidity

Air washers require a method of control of temperature to prevent freezing by too low an initial temperature, and to prevent over-humidification by too high temperatures of the air coming in contact with the water. There are available one method of hand control and five methods of automatic or semi-automatic control. The method of hand control is by the use of tempering heaters, divided into two or more sections in series, the outer section being turned on by hand whenever the outside temperature approaches freezing and the successive sections being turned on as the temperature drops below freezing. Where two sections are available it is usual to turn on the second section when the outside temperature goes below zero, and to turn on the third section, where necessary at temperatures below zero. The first, or outside section, must always be turned on full in cold weather to prevent freezing of the heaters. The steam supply to the second, or inside section, may be hand-regulated at all temperatures higher than about 10 deg. above zero.

The five systems of automatic regulation are:

1. The sections of the tempering heater are controlled both by variations in the outside temperature conditions and by an auxiliary control for one inside section

from a thermostat located on the discharge side of the air washer. (It is not possible ordinarily to control the temperature of the air entering the washer, except where there is an unusually long tunnel or duct for the thorough mixture of the air leaving the tempering heaters before it comes in contact with the thermostat).

2. By heating the spray water so as to maintain a temperature or dew point (as the air is then saturated) of the air leaving the washer at between 35 and 40 deg. This method does not necessarily require a tempering heater. It is preferable, however, to use one section for the purpose of tempering the air, should the washer be shut down; this to prevent freezing of the water when the apparatus is not in operation. More than one tempering section should never be used, except where temperatures may go considerably below zero; then the tempering sections may be turned on, one at about 20 deg. fahr., and the second at about 0 deg. fahr. The tempering section may be operated manually or by a thermostat connected with the outside air. The steam supply for water heating should be sufficient to heat and saturate the air at from 10 to 35 deg. fahr., when water heating is used in conjunction with a tempering section. This is to allow a sufficient margin for safety of operation.

3. By regulating the heat supplied either through tempering sections or through the spray water so that the water in the tank shall be kept well above the freezing point. Inasmuch as the wet-bulb temperature of the air and the water in the tank are but few degrees apart when the water in the tank is not heated directly, this method is a fairly effective and simple one. One permissible variation of this method is to use a thermostat in the air leaving the washer, controlling the dry-bulb temperatures at this point through regulation of the steam supply to the inside tempering section. The wet-bulb temperature of the air is controlled by means of a thermostat in the water leaving the eliminator plates and is held at the desired point by means of adding heat to the spray water. This will control exactly the temperature and relative humidity of the leaving air. Two or more tempering sections are required for this method.

4. The fourth method is desirable where recirculation is used and consists in maintaining the temperature leaving the washer at about 40 deg. by means of a thermostat located at this point controlling the admixture of fresh and return air through automatically operated dampers. This prevents over-humidification, eliminates danger of freezing, and effects the highest economy in cost, as no steam is required for either tempering or humidifying, except after the air has passed the washer.

5. The fifth method of automatic control is to reheat the air leaving the air washer to a definite thermostatically controlled temperature, and to control the relative humidity of the air by means of a hygrostat which operates either on the tempering sections to heat the air or which controls a water heater for the spray water.

Steam Requirements

Where the spray water is not heated it is necessary that the wet-bulb temperature of the incoming air be above the freezing point; otherwise the eliminator plates will coat with ice and stop up, even if the dry-bulb temperature of the leaving air is above the freezing point. It is necessary to heat zero air to 48 deg. in order that the wet-bulb temperature may be 35 deg. The temperature of the leaving air may then be expected to be approximately 39 deg. dry bulb and 35 deg. wet bulb, with a dew point of 31 deg. If the humidifying capacity of the washer is 75 per cent the additional heat required to furnish humidification is that indicated by the temperature drop of 9 deg., or 162 B.t.u. per 100 cu. ft. of air, or 1 b.hp. for every 3,400 cu. ft. of air per minute.

These are the minimum requirements for humidification, above those required for heating the air. Table 1 gives the heat required, from various outside entering wet-bulb temperatures, to various dew-point temperatures corresponding with various relative humidities at 70 deg.

These values are the total heat required for both heating and humidifying the air. The amount of heat required for humidifying only, may be found by subtracting from the values given, the heat required to raise the temperature of 1,000 cu. ft. of air per minute between the limits specified. The heat required for heating the air is given by the formula

$$H = 1{,}000\ \frac{t_2 - t_1}{55.5}$$

where

H = B.t.u. required to raise 1,000 cu. ft. of air from a temperature of t_1 to a temperature of t_2 deg. fahr. .

TABLE 1. HEAT REQUIRED TO RAISE 1,000 CU. FT. OF AIR FROM VARIOUS OUTSIDE ENTERING WET-BULB TEMPERATURES TO VARIOUS DEW-POINT TEMPERATURES AND CORRESPONDING RELATIVE HUMIDITIES AT 70 DEG. FAHR.

See Marks' Engineers Handbook.

WET-BULB TEMPERATURE OF ENTERING AIR, DEG. FAHR.	RELATIVE HUMIDITY, PER CENT AT 70 DEG. FAHR. (AND DEW POINT, DEG. FAHR.)					
	30% (37.25)	40% (44.5)	50% (50.5)	60% (55.3)	70% (59.6)	80% (63.5)
−10	1194	1452	1653	1860	2044	2245
0	984	1246	1447	1663	1840	2039
10	750	1025	1228	1445	1621	1822
20	510	779	983	1200	1377	1581
30	300	496	700	920	1097	1300
40	......	178	384	603	783	987
50	......	......	......	220	394	619
60	......	......	......	......	......	181

AIR FILTERS

Air filters are distinguished from air washers in that they clean the air without the use of water and without the addition of a water spray. They are usually of the following types:

1. The viscous filter, depending upon the dirt impinging on a surface covered with a viscous fluid or oil.

2. The dry filter, which removes the dirt from the air by straining or filtering it through cloth, felt or paper screens, the openings in which are too small to allow the passage of dirt, or which removes the dirt by passing the air through tortuous passages.

Viscous Air Filters

All of the so-called viscous type air filters operate on the principle of *adhesive impingement*. Investigation has shown that the dirt and dust in air, including the soot and carbons—the great destructive elements in modern ventilation work—are trapped and retained by successive impingements on oil coated surfaces. This is not a new idea—for years roads and floors have been oiled to keep the dust from flying about. Considerable ingenuity, however, has been shown in the various arrangements of metallic surfaces which are formed into filter units and made available for air cleaning work.

While the arrangement of filtering media and the kind of materials used are almost unlimited, there are certain rather definite requirements for a practical commercial filter, and these have limited the possible constructions.

To fulfill the essential requirements of clean air an air filter must:

1. Be efficient in dirt removal.
2. Interpose low resistance to air flow.
3. Have a large dust holding capacity.
4. Be easy to clean and to handle.

There are, of course, other factors of importance, including weight, strength and permanency.

In order to secure maximum efficiency, it is necessary to divide the air into innumerable fine streams; the more intimately and frequently the air is brought into contact with the viscous-coated media the better the cleaning will be. Practically seven impingements are sufficient; more will give better service.

As the dirt and dust are leached out of the air and collected on the adhesive coated surfaces, additional supplies of binding liquid are required in order to bind further layers of dirt. For this reason filters are usually designed to hold somewhere within the unit, additional supplies of the binding liquid, capable of distribution by capillary attraction, or by some mechanical means.

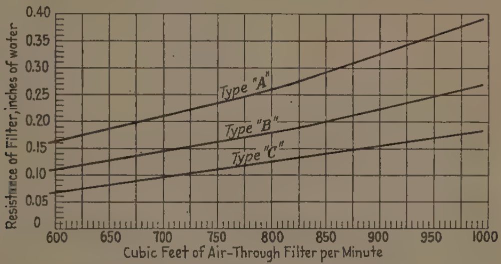


FIG. 1. RESISTANCE TO AIR-FLOW OF A TYPICAL UNIT AIR FILTER

Investigations in this country and abroad demonstrate that the first impingement of dust-laden air on a viscous-coated surface removes 60 per cent of the dust, the next impingement takes 60 per cent of what then remains—that is, 24 per cent—the next impingement removes 9.6 per cent, etc. The principle of progressively packed media is embodied to a greater or less extent in all unit viscous filters. This arrangement gives relatively large spaces for the collection of dirt in the front part of the filter, where the bulk of the solids are taken out, without undue increase in resistance. At the back of the filter the openings are smaller and finer dust particles are removed.

The binding liquid used with these filters should be odorless, fire-proof, and germicidal in its action.

Unit Viscous Filters

Unit viscous filters usually are made up of a number of separate filter units with a frame or frames designed to support them and arranged so that the filter units are easily removed from the frame for cleaning and recharging.

If the unit filters are cleaned *progressively* the resistance and volume of air delivered may be kept practically constant. By cleaning a predetermined number of filters every week—or every month, as the case may be—the resistance and consequent air volume can be held at any desired figure.

Obviously, the resistance and efficiency of a unit air filter of the adhesive impingement type depends upon the velocity at which the air is handled and the condition of the unit—that is, whether the unit is clean or dirty.

The efficiency of the unit is usually highest after it has accumulated approximately 75 per cent of its maximum load of dirt, as the dirt and dust accumulated in the cell usually are efficient media for the further collection of solids from the air.

The resistance of the commercial unit air filter of the adhesive impingement type varies from 1/16 to 3/8 in. water gage when clean, depending, of course, upon the design selected. As dust accumulates in the filter, usually the resistance and cleaning efficiency rise. (See Figs. 1 and 2).

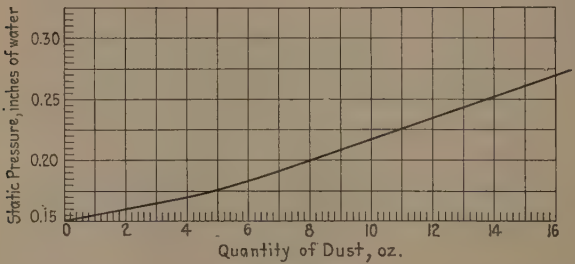


FIG. 2. CHART SHOWING CHANGE IN RESISTANCE DUE TO DUST ACCUMULATION

Fig. 1 shows the resistance to air flow of a typical unit air filter, which is built in three types, having, respectively, 1/8, 1/4 and 3/16 in. water gage resistance when operated at a velocity of approximately 365 lin. ft. per minute. Fig. 2 shows the change in resistance due to dust accumulation. Under actual operating conditions one pound of dust represents about eight weeks of normal service. The resistance of an installation of filters under the conditions cited could be held at any point between 0.15 in., the resistance of a clean filter, and 0.27 in., the resistance after accumulating one pound of dust, by cleaning a sufficient number of cells each week to maintain the desired average.

To make sure of proper periodic cleaning of the units the installation of a standard draft gage is recommended.

Proper washing, drying and recharging equipment should be installed as convenient to each set of filters as possible.

Automatic Viscous Filters

Unit air filters have certain limitations in the amount of dirt which can be handled. If the dirt reaches the filter too rapidly, or in such quantities that the adhesive liquid does not have sufficient opportunity to soak through and wet the successive layers, the cleaning efficiency drops off. Removals for unit filter cleansing sometimes prove so frequent as to be objectionable or impracticable.

This fact, and perhaps the age-old effort to eliminate dependence where possible on the human element, brought forth the self-cleaning or automatic viscous filters, several distinct types of which are now available.

In the main these filters are based on the same fundamental principles as unit viscous filters. All utilize the principle of adhesive impingement. Various ingenious arrangements of struts, woven wires or foraminous metal sheets are arranged to move progressively through the bath of charging liquid, the dirt thus being flushed off, while in other types the filter media itself remains stationary, and the charging liquid moves over the dirt-collecting surfaces, flushing off the accumulated dirt at regular intervals, usually once in 24 hours.

Dry Air Filters

There are now available various types of unit and automatic air filters in which the dust is impinged upon or filtered out through felt, cloth, paper, etc., screens. These devices require no adhesive liquid of any kind, but depend on the straining or screening action of the filter media.

The filters are cleaned or reconditioned by rapping or vibrating the screens. In some cases the air flow is reversed during the reconditioning period. Practically all of the various types of dry filter media have a definite length of useful life depending upon the nature and strength of the texture.

Dry filters, as a class, therefore, differ from the all-metal viscous type in that their filtering media must be replaced periodically as the end of its useful life is reached.

Because of the close texture of the filtering media used in most of the dry filters, the surface velocity, or velocity of the air through the media is considerably lower than in the viscous types. The initial resistance, or the resistance when the filter media are clean, is likewise somewhat lower. The usual practice is to allow the dirt to accumulate on the filtering surface until the resistance has reached a predetermined maximum. At this point the load of dirt is removed by some mechanical means and the filter thereby reconditioned. A constant resistance such as is obtained with the automatic viscous filters cannot be maintained, in a practical way, with the present dry filters. However, an average operating resistance results, provided the filter is properly maintained and reconditioned.

DUST REMOVAL EFFICIENCY

The efficiency in dust removal of air-cleaning devices can be determined by means of tests made with air at stated capacities and with dust of definite quantity and quality. There are a number of excellent commercial instruments available for this purpose. The percentage of dust removal for commercial air-cleaning devices should range between 80 and 98 per cent, and the minimum removal under such conditions should be specified and guaranteed by the manufacturer.

AIR CLEANER TESTING CODE

A Code for Testing Air Cleaning Devices is now being developed by the American Society of Heating and Ventilating Engineers and considerable research is being carried on at the University of Minnesota.

CHAPTER 9

UNIT HEATERS AND AIR-CONDITIONERS

Functions of Unit Heaters; Types; Entering and Delivery Air Temperatures; Ratings and Capacities; Arrangements of Heaters; Direction and Location of Discharge; Boiler Capacity; Automatic Control; Quietness of Operation; Connections; Direct Fired Units; Unit Air Conditioners; Cooling Units; Unit Ventilating Machines.

IN this chapter are described the various types of *unit* heating, air conditioning, cooling and ventilating systems.

UNIT HEATERS

The industrial unit heater is composed of a heating element enclosed by a casing in which a power driven fan or fans are mounted. The fans draw or force air over the heating surface, and discharge it in selected directions.

Unit heaters usually are placed directly within the room to be heated. Unit heaters have the inherent characteristic of delivering and distributing the air by mechanical impulse. In many buildings this feature results in exceedingly economical and successful heating.

Functions of Unit Heaters

Unit heaters are designed to:

1. Circulate the air in the building at a rapid rate.
2. Promote uniformity of temperature and quick heating-up.
3. Direct the heated air so as to accomplish the positive and rapid placing of the heat where it is effective.
4. Counteract excessive temperature against cool roofs or ceilings, a concomitant of most other types of heating.
5. Reduce the number of heat emitting units and simplify piping and installation.
6. Increase the capacity of the heating surface by passing the air over it at high velocity.
7. Provide a system by which room temperatures are readily controlled manually or by thermostats.

In addition to their prime function of heating buildings, unit heaters may be adapted to a number of industrial processes, such as drying, curing, etc., with which the use of heated air in rapid circulation with uniform distribution is of particular advantage. They may be used for moisture absorption, such as fog removal in dye-houses or for the prevention of condensation on ceilings or other cold surfaces of buildings in which process moisture is given off. When such conditions are severe, it is necessary that the heaters draw air from outside in enough volume to provide a rapid air change and that they operate in conjunction with ventilators or fans for exhausting the moisture-laden air. (See discussion of condensation in Chapter 2.)

Types of Unit Heaters

There are many types of unit heaters available. Most of them employ heating coils to be supplied with steam or hot water. Some are designed primarily for mounting on the floor, whereas others are designed for suspension overhead. Heating surfaces in the form of pipe coils, non-ferrous tubes or shapes with extended surfaces, cast-iron, and pressed and built-up sections of the cartridge or automotive type are all used in unit heater construction.

Among the unit heaters available are types having from one to four outlets per heater which may be arranged to discharge in selected directions and which will project their heating effect over distances of from 30 to 200 ft. from the heater, depending upon the capacity of the heater and upon the design of the fans and outlets. These heaters have been successful when placed as far as 400 ft. from each other. This makes it possible to select the heater location best suited to the production layout in factories. There are also available propeller fan type heaters of smaller capacity with outlet velocities of from 300 to 600 ft. per minute, and these may be placed from 60 to 100 ft. apart.

Heating Mediums

Unit heaters are made to operate on hot water, or with steam at high pressure or at vapor pressure. When high pressure steam is used, the heater must of course be especially designed for that purpose.

The present day tendency is to use steam at low pressure when the boiler supplies steam for heating purposes only, and when the transmission lines are short. Many industrial plants, however, generate steam at high pressure either for long distance transmission or for process uses. When such high pressure steam is available in sufficient quantity for the peak load, it is economical usually to use high pressure unit heaters. Thus the line pressure may be turned into the units directly without reducing valves and the condensation may be trapped to overhead returns when desired. Smaller coils may be used in high pressure heaters to lessen their cost and to produce a final temperature which will not be too high. Steam turbines may be used for fan power, each exhausting directly into its own heater.

Procedure for Determining Heat to be Supplied

The heat losses of a building to be equipped with unit heaters are determined in the same manner as for any other heating system, excepting so far as the unit heaters may change the air temperature at the ceiling or at the mean height of the walls. (See Chapter 2).

Unit heaters may be arranged to recirculate the air or to supply warmed air from the outside for ventilation or to make up air exhausted.

If all or a part of the air is to be taken in from out-of-doors, the heat necessary to warm this air from the outside temperature to the inside temperature must be added to the transmission or other losses. Unit heaters of the number and size needed to furnish the total heat required are then selected from the manufacturers' rating tables, using these ratings at the steam pressure to be used and at the temperature at which the air will enter the heater.

Temperature of Air Entering Heater

For recirculating heaters with intakes at the floor level, use the temperature to be maintained in the room as the temperature of the air entering the heater. Where suspended heaters are used without any intake boxes extending down to the floor level, a higher entering air temperature should be used than that at which the room is to be maintained. With suspended heaters taking in air at some distance above the floor, the temperature variation from floor to ceiling may reach as much as 1½ deg. fahr. for each foot of elevation during periods when the maximum capacity of the heaters is required. Unit heaters taking in recirculated air at the floor level should maintain temperature differentials of less than 1 deg. per foot of elevation when the maximum capacity of the heaters is required. These temperature differences per foot of elevation are less than the corresponding variations per foot of elevation for spaces heated by direct radiation.

Delivery Air Temperature

A rapid recirculation or turnover of the air in the room makes for fuel economy. This calls for the selection of heaters having a liberal air capacity for the required heat output, which in turn means a relatively low final temperature. Extremely low final temperatures can be had only at the expense of larger heaters and increased power, so that a commercial limit is imposed. Contributing conditions vary too widely to permit of a suggested standard, but in general for heating purposes, it is advisable to use a delivery temperature which is 70 deg. or less above the average room temperature desired.

Ratings and Capacities

It is standard practice to rate unit heaters in B.t.u. per hour at a given temperature of air entering the heater and at a given steam pressure maintained on the coil. Steam at 2 lb. pressure and air entering at 60 deg. fahr. are used as the standard basis of rating. The capacity of a heater increases as the steam pressure increases, and decreases as the entering air temperature increases. The heat capacity for any condition of steam pressure and entering air temperature may be calculated approximately from any given rating by the use of factors in Table 1. This table is accurate within 5 per cent.

The ratings customarily published for unit heaters, apply only for recirculation and free discharge, unless otherwise noted in the rating tables. If outside air intakes, filters or ducts on the discharge side are used with the heater, proper consideration should be given to the reduction in air and heat capacity that will result because of this added resistance.

The percentage of this reduction in capacity will depend upon the characteristics of the heater and on the type, design and speed of the fans employed, so that no specific percentage of reduction can be assigned for all heaters for a given added resistance. In general, however, disc or propeller fan units will have a larger reduction in capacity than housed fan units for a given added resistance, and a given heater will have a larger reduction in capacity as the fan speed is lowered. When confronted with this problem the ratings under the conditions expected should be secured from the manufacturer.

When steam supplied to the heaters contains superheat, the capacity of the heater will be but slightly less than with saturated steam at the same pressure. Recent tests conducted at the University of Kentucky indicate that the reduction of capacity from this cause is negligible for superheat up to 50 deg. and will not exceed 3½ per cent for any degree of superheat.

TABLE 1. CONSTANTS FOR DETERMINING THE CAPACITY OF UNIT HEATERS FOR VARIOUS STEAM PRESSURES AND TEMPERATURES OF ENTERING AIR

(Accurate within 5 per cent)

STEAM PRESSURE LB.	TEMPERATURE OF AIR ENTERING HEATER												
	−10°	0°	10°	20°	30°	40°	45°	50°	55°	60°	65°	70°	75°
0	0.975	0.93	0.89	0.84	0.80	0.76	0.73	0.71	0.69	0.67	0.64	0.62	0.60
2	1.01	0.96	0.92	0.87	0.83	0.79	0.76	0.74	0.72	0.70	0.68	0.65	0.63
5	1.04	**1.00**	0.96	0.91	0.87	0.82	0.80	0.78	0.76	0.74	0.71	0.69	0.67
10	1.06	1.05	1.01	0.97	0.92	0.88	0.85	0.83	0.81	0.79	0.76	0.74	0.72
15	1.15	1.10	1.05	1.01	0.97	0.92	0.90	0.88	0.86	0.83	0.81	0.79	0.76
20	1.18	1.14	1.09	1.05	1.00	0.96	0.94	0.92	0.89	0.87	0.85	0.83	0.81
30	1.25	1.21	1.16	1.12	1.08	1.03	1.01	0.98	0.96	0.94	0.92	0.90	0.88
40	1.30	1.26	1.22	1.17	1.12	1.08	1.06	1.04	1.02	1.00	0.97	0.95	0.93
50	1.35	1.31	1.27	1.22	1.18	1.13	1.11	1.09	1.07	1.04	1.02	1.00	0.98
60	1.39	1.35	1.31	1.26	1.22	1.18	1.16	1.13	1.11	1.09	1.07	1.05	1.03
80	1.49	1.43	1.38	1.34	1.29	1.25	1.23	1.20	1.18	1.16	1.14	1.12	1.10
100	1.53	1.49	1.44	1.40	1.35	1.31	1.29	1.26	1.24	1.22	1.20	1.18	1.16
125	1.59	1.56	1.51	1.46	1.42	1.37	1.36	1.33	1.31	1.29	1.27	1.24	1.22
135	1.61	1.57	1.53	1.48	1.44	1.39	1.37	1.35	1.33	1.30	1.28	1.26	1.24
140	1.62	1.58	1.54	1.49	1.45	1.41	1.38	1.36	1.34	1.32	1.29	1.27	1.25
150	1.64	1.60	1.55	1.51	1.46	1.42	1.40	1.38	1.35	1.33	1.31	1.28	1.26

Note.—To determine capacity at any steam pressure and entering temperature, multiply constant from table by rated capacity at 0 deg. entering and 5 lb. pressure.

Arrangement of Heaters

Heaters may be distributed through the central portions of a room discharging toward exposed surfaces, or may be spaced around the walls, discharging along the walls and inward as well, when there are considerable roof losses.

In general, it is better to direct the discharge from the unit heaters in such fashion that rotational circulation of the entire room content is set up by the system rather than to have the heaters discharge in random and in counter-directions.

Direction and Location of Discharge

Various types and makes of unit heaters are illustrated in the Catalog Section of THE GUIDE. Usually hot blasts of air in working zones are objectionable, so heaters mounted on the floor should have their discharge outlets above the head line and suspended heaters should be placed in such manner and turned in such direction that the heated air stream will not be objectionable in the working zone. In the interest of economy, however, the elevation of the heater outlet and the direction of discharge should be so arranged that the heated air shall be brought as close to the head line as possible, yet not into the working zone.

Boiler Capacity for Unit Heaters

The capacity of the boiler should be based on the rated capacity of the heaters at the lowest entering air temperature that will occur, plus an allowance for line losses. Ordinarily for recirculating heaters the lowest entering temperature will occur at the beginning of the heating period and is usually taken as 40 deg., while for heaters taking air from outdoors the lowest entering temperature will be the extreme outdoor temperature expected in the district. No greater allowance in boiler capacity beyond the calculated heat demand need be added in order to supply unit heaters than for any other type of system.

It is unwise to install a single unit heater as the sole load on any boiler, particularly if the unit heater motor is started and stopped by thermostatic control. The wide and sudden fluctuations of load that occur under such conditions would require closer attendance to the boiler than is usually possible in a small installation. Where oil or gas is used to fire the boiler, it is possible by means of a pressurestat to control the boiler, in response to this rapid fluctuation. In most cases, however, and particularly where the boiler is coal-fired, it is advisable to use two or more smaller heating units instead of one large unit.

Steam pressures below 5 lb. can be used with safety for recirculating unit heaters when their coils are designed for the purpose and when proper provision is made for returning the condensate. If heaters are to take in air that may be at a temperature below freezing, however, a steam pressure of not less than 5 lb. should be maintained on the heater coils.

Automatic Control

There are two general methods of automatic control that may be applied to a unit heater installation. One is to start and stop the unit heater motors individually or in a group by means of a room thermostat. The other is to control the steam supply either to individual units or a group of units by means of a graduated-acting valve, operated from a room thermostat. Where steam valve control is used, the return system must be equipped with a vacuum pump, as a considerable pressure difference between supply and return pipes necessarily exists in all unit heaters.

A combination of these two methods is sometimes used, wherein the steam supplied to the units is cut off completely before the unit heater motor is stopped and is turned on just after the motor is again started. The function of this control is to cool off the heater and prevent possible discomfort to persons close to the heater from the increased radiant effect of the heater if steam is left on the coils when the motor is stopped. This is accomplished by two thermostats, one controlling the motor and the other controlling the steam valve. The latter is set for a wider operating range than the former. With this combination control there is some possibility of draft-complaint if the fan delivers cool air.

Graduated-acting control of the steam valve should not be applied to heaters with outside air connections unless protection against freezing is also used. This protection can be accomplished by separating the heater coil into two parts, one of which acts as a tempering coil and is controlled from an outside thermostat, which will keep steam at full pressure on the coil whenever the entering air is below freezing and which will cut off the steam when the entering air goes above freezing. The main coil is controlled from the room thermostat and is depended upon for temperature regulation. Another method of protection is to immerse in the return condensate a thermostat which controls a positive-acting by-pass valve which will admit additional steam if the temperature of the condensate falls to the freezing point. This is purely a safety device and assumes that no condition of normal regulation will require enough throttling to make freezing possible. If this were not the case this method would not be suitable, as it prevents regulation beyond the point where the by-pass opens.

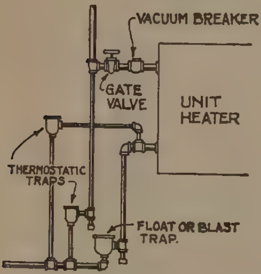


FIG. 1. UNIT HEATER CONNECTIONS WHERE CONDENSATION IS RETURNED TO VACUUM PUMP

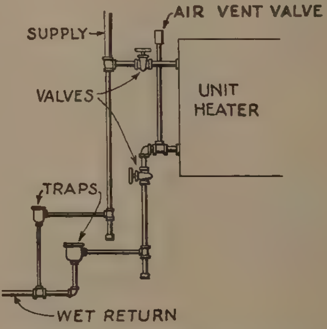


FIG. 2. UNIT HEATER CONNECTIONS WHERE CONDENSATION IS RETURNED TO BOILER THROUGH WET RETURN

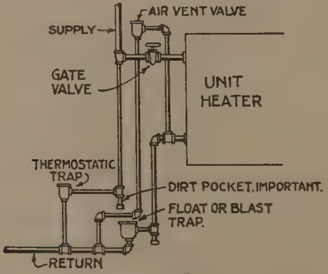


FIG. 3. UNIT HEATER CONNECTIONS WHERE CONDENSATION IS RETURNED TO CONDENSATION PUMP OR HOT WELL

As a precaution against allowing the unit heater motors to continue to run if the steam supply fails or is for some reason shut off, either a pressurestat or thermostat in the steam line may be installed to stop the motor when the pressure or temperature in the supply line drops below a selected point. For a further discussion of this subject, see Chapter 17, Automatic Heat Control.

Quietness of Operation

In selecting unit heaters, attention should be given to the degree of quietness required for the installation.

No given fan speed may be applied as a measure of relative quietness to fans of different design and proportions. Quietness is a function of type, diameter, blade form and other variables besides speed, and all these must be taken into account. In general small fans can be run at higher motor speeds than can large fans with equal quietness.

Unit Heater Connections

Piping connections for unit heaters are similar to those for other types of fan-blast heaters. Typical connections are shown in Figs. 1, 2 and 3.

One-pipe gravity and vapor systems are not recommended for unit heater work.

On two-pipe gravity, or on pump and receiver systems the return from each unit should be fitted with a heavy duty or blast trap and an air valve should be connected into the return header of each unit. Pressure-drop must be compensated for by elevation of the heater above the water line of the boiler or of the receiver.

On vacuum systems the return from each unit should be fitted with a large capacity trap to discharge the water of condensation and with a thermostatic air valve for eliminating the air, or with a heavy duty trap for handling both the condensation and the air, provided the air finally can be eliminated at some other point in the return system.

On high pressure systems the same kind of traps may be used as with vacuum systems, except that they must be constructed for the pressure used. If the air is to be eliminated at the return header of the unit, a high pressure air valve can be used; otherwise the air may be passed with the condensate through the high-pressure return trap.

The connections for steam and return piping to unit heaters must always be calculated on the basis of the high heat emission or condensation rate of such devices, usually by reducing the heat to be supplied to square feet of equivalent radiation by dividing by 240, and then using the pipe-size tables given in Chapter 20. The supply valve must be at the high point, or provision must be made for draining the pocket above this valve when the valve is closed.

Direct Fired Units

The foregoing discussion relates generally to units in which steam, vapor, or hot water are used as the heating medium. On rare occasions electrical resistances are used as the heating element. These are applied only where electric power is abundant and cheap and where other forms of fuel are scarce and expensive.

Where steam or hot water are not available the direct-fired type of heater is used. The heating element is a warm-air furnace in which coal, coke, oil or gas is burned directly. This heating element is enclosed in a casing through which a fan maintains a rapid air current by pressure. This type of heater is often used for temporary heat during building construction or where the installation of a steam or hot water plant is for some reason not justified.

UNIT AIR CONDITIONERS

For a more complete discussion of the subject of air conditioning, see Chapter 7.

With the unit type of air conditioner the requirements of a given room are met by installing the necessary number of standard complete air conditioning units, usually without any distributing duct work; the necessary air distribution being accomplished by the distribution of the units themselves. Each unit is a complete air conditioning plant in itself including spray heads or nozzles (humidifier and dehumidifier) air re-heater, fan, spray pump, automatic control, etc. These units usually are built in graduated standard sizes having capacities of from 2,500 to 10,000 cu. ft. per minute each.

Advantages of Unit Air Conditioners

The principal advantages are that the desirable results of the indirect humidification system can be applied to old buildings without installing duct work. Also where manufacturing processes are changed and departments are sub-divided or enlarged the units may easily be moved or increased in number to suit the new requirements. They are also particularly adapted for use by tenants of rented buildings since they are movable and do not become a part of the property when installed. Often there is more than sufficient saving by avoiding the elaborate duct work necessary with a central air conditioning plant to pay for the cost of the increased number of units. Standardized production and the lower costs inherent thereto are also an added advantage. Conditioning units are particularly advantageous for manufacturing plants which require different air temperatures and humidities in various rooms. Trouble with one unit does not cripple other units. Owners may approach the ultimate investment for air conditioning gradually, buying a unit at a time as expediency dictates.

Disadvantages of Unit Air Conditioners

Air conditioning units, especially in factories where considerable dust and lint occur, require frequent attention and cleaning. Attention must be given the adjustment of controls. A multiple unit installation, therefore, involves somewhat more attention than does a single unit located in the basement. In dehumidifying plants there is a decided advantage in having a single air conditioning unit located convenient to the refrigerating apparatus rather than to have a large number of water supplies and returns. For dehumidification, the central station system is to be recommended where more than three unit conditioners would be required.

Types of Unit Air Conditioning Equipment

Unit air conditioning equipment may be of the following types:

1. The air washer type which does not control the moisture content or temperature of the air but which simply cleans the air.
2. The humidifying type which controls the relative humidity without washing the air or controlling its temperature.
3. The complete air conditioning unit, which washes the air, controls its moisture content and which heats or cools the room within which the unit is located.

An air conditioning unit may be so designed that it will draw in air from the room or enclosure in which it is placed or from the outside, or by the aid of mixing dampers, may draw any predetermined mixture of inside and outside air. This entering air passes through one or more spray or mist chambers, in which space moisture is either added to or removed from the air in accordance with the temperature of the air and of the spray water. At the same time the air is washed substantially free of dust and solid matter in this chamber. The air next travels between the customary labyrinth eliminator plates to lose its entrained water. A suitably located fan assembly causes the air to flow over a heating element before being delivered to the room. A motor-driven centrifugal pump or other means is used to deliver water from the tank built into the base of the unit to the spray heads, mist nozzles or other atomizing apparatus. In some makes of unit air conditioners, other means than spray nozzles are used to produce the required water spray or mist for the transfer of heat from air to water or vice versa. Automatic instruments control the condition of the leaving air by regulating the temperature of the spray water and also by varying the amount of steam supplied

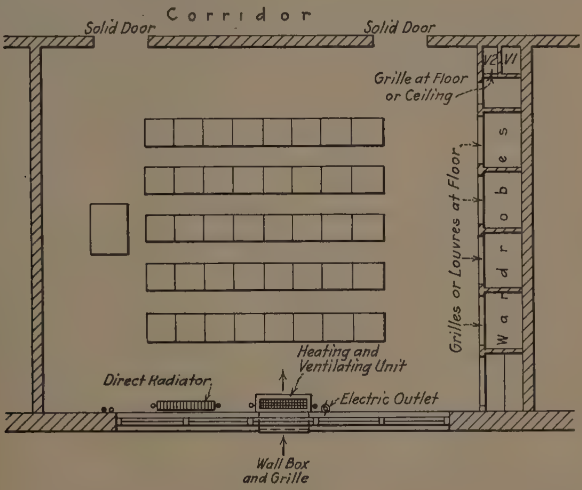


FIG. 4. SPLIT OR MODIFIED INDIVIDUAL VENT FLUE SYSTEM

to the air heater. Such instruments usually are placed in the path of the return air as it enters the unit to be conditioned, as the entering air is a sample of room air. The spray water can be heated by an ejector or by a closed type heater.

For dehumidifying work cold water may be supplied under automatic control as needed. It usually is found best where refrigeration is used to employ a separate water cooler located in close proximity to the compressors and condensers, rather than to use direct expansion coils or brine coils within the air conditioning units.

COOLING UNITS

Air cooling units are of two general kinds, the coil type, which is similar in appearance to the floor-mounted heating unit, and the brine spray type, which is similar in appearance to the floor mounted air conditioning unit. The coil type may use cold water, brine, or may use ammonia, or other refrigerants, while the brine spray type normally uses pre-cooled brine, or includes a refrigerating coil for chilling the brine.

The coil type unit is identical in operation with the heating unit except that the coil is supplied with cold water or a refrigerant instead of with steam. The coil must be made of bare pipe, since a finned surface would soon clog with frost.

The coil type unit is less expensive than the brine spray type, and may be used where there is not an excessive amount of moisture present. It is rapidly replacing the bunker coil in storage rooms for fur, meat, vegetable, poultry, and some dairy products.

In rooms containing excessive moisture, such as pre-chill rooms in slaughter houses, the coil type unit is not satisfactory unless the room temperature is carried above 40 deg. If lower room temperatures are required, the coil of the unit would frost excessively, thereby reducing its output. For these conditions, the brine spray unit has the advantage of having no coil to frost (the coil, if used, is for the purpose of chilling the brine) and the moisture which is extracted is deposited in the spray, drops to the tank and escapes through the overflow.

The specific gravity of the brine solution must be frequently checked and when necessary, increased so that the brine will not become diluted to the point where it will freeze at the conditions under which the unit is expected to operate.

In addition to showing a saving on installation and first cost, the cooling unit gives a positive air circulation and a much more even distribution of temperature than previous methods of cooling. On account of this positive circulation and even distribution, a slightly higher room temperature may be carried than is customary with bunker coils, which gives an operating economy and results in improved quality of some products.

Usually refrigerating coils must be defrosted at intervals. An advantage of the unit system is that the cooling surface is concentrated in one point, and melted frost or condensation is collected in the drip pan, which may be connected to the sewer if desired.

Under certain room conditions, when properly applied, cooling units are virtually self-defrosting.

Cooling units, like heating units, lend themselves to alteration of plant layout or expansion, since they are easily disconnected and reinstalled at a new location.

UNIT VENTILATING MACHINES

A unit heating and ventilating machine for schoolrooms and public buildings consists usually of a small rectangular steel cabinet, and has the following essential parts:

1. Outside air inlet.
2. Duct filter (optional).
3. Motor and fan assembly.
4. Radiator or heating element.
5. Temperature control arrangement (may be by damper or by supply valve).
6. Outside air damper.
7. Recirculating damper (optional).
8. Discharge grille or diffuser.

This machine often is partly recessed into the walls, so as to minimize interference with aisle-passages.

When the outside air inlet damper is open and the fan is operated the air is drawn immediately from out-of-doors, and is forced by the fan through the cleaning and heating apparatus contained in the machine.

All of the air handled by the fan may be driven through the convector-heater and thence to the room, or part may be by-passed around the convector, depending on temperature requirements of the room. In some cases, instead of a by-pass damper for controlling the temperature, this is accomplished by valves which control the heat supply to all or to part of the convector-radiator inside the machine.

In some machines the closing of the outside air damper simultaneously opens the recirculating grille at the floor line, so that the air can circulate by gravity through the radiator if no dust filters are present.

Split System

In the split system shown in Fig. 4, the unit is used for ventilation only, delivering the air to the room at very near the room temperature, sufficient separate direct heaters being placed in the room to heat it to the desired temperature, independently of the unit. With the split system the separate direct heaters tend to improve the air circulation and diffusion within the room, since they constantly pull the cold air from the floor, warm it and use it to counteract the window chill.

The split system permits of operation of the room during failure of electric current, since the radiator-conductors will furnish heat, but on the other hand it permits a careless operator to avoid the bother of operating the ventilating equipment. On the whole the split system in normal operation probably gives the best satisfaction where attention and maintenance are mediocre.

In some cases the amount of direct radiation required to maintain the desired room temperature is deficient by deliberate intention of the designer. With this arrangement the ventilating machine must have sufficient surplus heating capacity, over and above that required for ventilation, to take care of the heating requirements. Owing to the variations in outside temperature and to the effect of the sun and of changing intensity of occupation it is difficult to maintain satisfactory temperature regulation with most split systems unless there is enough direct radiation to heat the room independently of the ventilating apparatus.

Blast System

The all-blast system (Fig. 5) employs the unit ventilating machine alone, its capacity being large enough both for ventilation and for supplying the heat loss. Direct radiation is omitted altogether.

The blast system requires that all heating shall be accomplished by the machine. It becomes necessary then that the fan shall be running whenever the room is to be occupied and this gives reasonable assurance of ventilation and of efficient attention by the custodian. With the all-blast system the distribution of the air within the room probably is not as perfect as with the split system, and more drafts are liable to be encountered, since there must of necessity be wide and rapid variations in the temperature of the air delivered by the machine in order to control the room temperature.

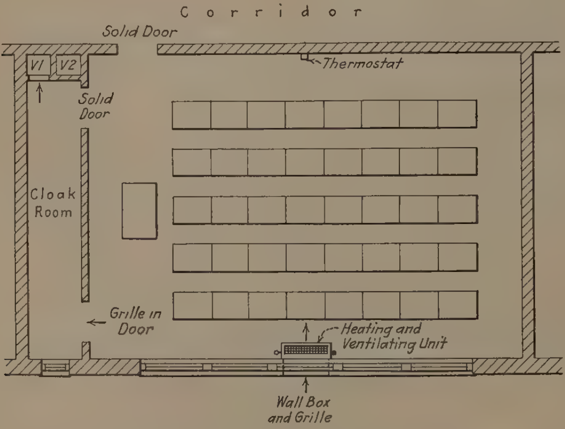


FIG. 5. INDIVIDUAL VENT BLAST SYSTEM

Location of the Ventilating Unit

The best distribution of the air is obtained usually when the machine is placed in the center of the exposed side of the room.

Location of the Air Intake

In nearly all installations the intake for outside air is placed just above the floor line and as symmetrically as possible with reference to the center of each room.

Automatic Heat Control

Automatic heat control is exceedingly desirable with all unit ventilating machines. An intermediate-acting thermostat should be arranged so that on a rising room temperature the thermostat will function to operate the damper very slowly, and to hold it in an intermediate position. If the damper operation fails to control the temperature rise (as in mild weather) the thermostat should then bring about the closing of the steam supply valve to the convector in the machine.

It is important that the thermostats used with unit ventilating machines shall be of the super-sensitive type so as to produce graduated control of the temperature.

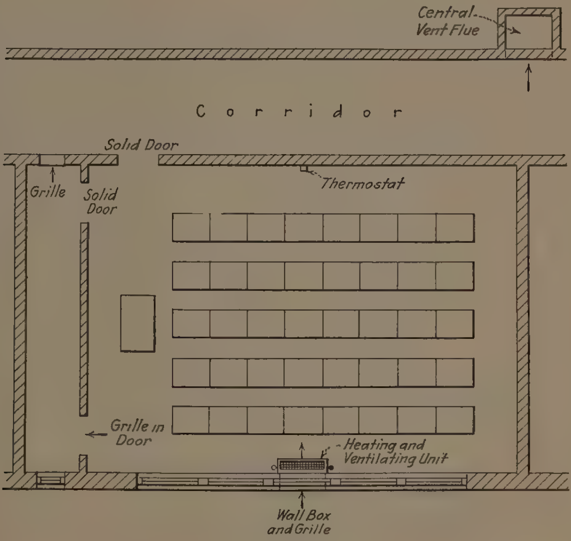


FIG. 6. CORRIDOR VENT BLAST SYSTEM

Pneumatic Damper Control

As part of the automatic system of temperature regulation, it is desirable to include manual pneumatic operation of the outside air inlet dampers so that these dampers on all of the units throughout the building, or on any group of units, may be opened or closed from a central point. If recirculating units are used these dampers also may be operated by remote pneumatic agencies.

It is quite helpful to group the manual control of the units in accordance with the points of the compass. The inlet dampers on the units to the North, South, East and West sides of the building may each be controlled by separate manual switches. Thus when wind conditions are severe on one side of the building the group of units on that side may be started at an earlier hour in the morning.

Vent Openings

The size and location of the vent outlet is important. In many cases the sizes for public buildings are regulated by law, but the location of the vents generally is left to the discretion of the engineer.

The best results have been obtained with a velocity through the vent openings nearly equal to that at which the air is introduced into the room, thus maintaining a slight pressure in the room. Calculated velocities at the vent openings of from 600 to 800 ft. per minute produce the best diffusion results from this system.

The cross-sectional area of the vent flue itself may be figured on the basis of 20 sq. in. of flue for each 100 cu. ft. per minute. Thus the vent flue area of a flue for a room equipped with one 1,200 c.f.m. unit ventilating machine would be 240 sq. in. The area of vent flue opening from the room may be figured on the basis of 25 sq. in. per 100 c.f.m.

The vent opening should not be placed directly opposite the unit, since the incoming air when introduced at lower than room temperature falls to the floor and moves directly toward this vent opening, causing possible floor drafts and in any event causing failure properly to cool the occupants of the room.

In buildings provided with wardrobes or cloakrooms the vents may be so located that the air shall pass through these spaces, heating and ventilating them with air which otherwise would be passed to the outside without being used to the best advantage. Many State codes for ventilation of public buildings make this arrangement mandatory.

In rooms without wardrobes or cloakrooms the vent flue may be located diagonally opposite the unit, and two such flues generally are desirable, one near each opposite interior corner of the room. This gives the air an opportunity to mix thoroughly with the room air before dropping to the vent opening.

Individual and Corridor Vent Flue Systems

The individual vent flue system and the corridor vent flue or central vent flue system are the methods generally used with unit ventilating machines.

The individual vent flue system, Fig. 5, provides for separate vent flues from each room.

The corridor vent or central vent outlet system, Fig. 6, provides for outlets centrally located to take care of a group of classrooms, the air passing from the classrooms, wardrobe or cloakroom to the corridor, and from the corridor to the central outlets. The grilles between the wardrobes and corridors may be near the ceiling, provided the air leaves the classroom to enter the wardrobes below the breathing line in the classrooms. A velocity of 800 to 900 ft. per minute may be used for the central outlet from the corridor.

Where the law and where the type of building construction will permit, the escaping spent air from the building may circulate throughout the attic on its way out.

CHAPTER 10

HEATING BY COAL

Composition, Kinds and Combustion of Coal; Hand Firing; Mechanical Stoker Firing; Storage Space.

COAL, because of its abundance and low price, has been used in preference to other fuels for heating purposes in most localities.

All coals are of vegetable origin, and are the remains of prehistoric forests. Destructive distillation, due to great pressures and temperatures, has resolved the organic matter into its exceedingly complex constituents; among which are carbon, hydrogen, oxygen, and other substances, in varying proportions. Time, depth of bed, disturbance of bed, and intrusion of extraneous mineral matter have produced the variations which are noted in the degree of evolution from vegetable fiber to hard coal. This variation is shown chiefly in the content of carbon, and Table 1 shows the steps of such variation.

COMPOSITION OF COAL

The uncombined carbon in coal is known as fixed carbon. Some of the carbon constitutent is combined with hydrogen, and this, together with other gaseous substances driven off by the application of heat, forms that portion of the coal known as the volatile matter. The fixed carbon and the volatile matter constitute the combustible.

The oxygen and nitrogen contained in the volatile matter are not combustible, but custom has applied this term to that portion of the coal which is dry and free from ash, thus including the oxygen and nitrogen in the combustible.

KINDS OF COAL

The kinds of solid fuel in general use are anthracite, semi-anthracite, semi-bituminous, bituminous, lignite and coke. They are classed according to their fixed carbon and volatile matter content. Analyses typical of each kind are shown in Table 2.

Anthracite Coal

Anthracite coal ignites slowly, but when in a state of incandescence its radiant heat is very great. Its flame is short and of a yellowish blue tinge and it can be burned with practically no smoke. This coal does not swell when burned although it contains from 3 to 7.5 per cent of volatile matter.

Semi-Anthracite Coal

Semi-anthracite coal kindles more readily, because of its higher content of volatile combustible, and burns more rapidly than anthracite. It has

Table 1. Approximate Chemical Changes from Wood Fiber to Anthracite Coal

Substance	Carbon	Hydrogen	Oxygen
Wood Fiber	52.65	5.25	42.10
Peat	59.57	5.96	34.47
Lignite	66.04	5.27	28.69
Bituminous Coal	75.06	5.84	19.10
Semi-Bituminous Coal	89.29	5.05	5.66
Anthracite Coal	91.58	3.96	4.46

less density, hardness, and metallic luster than anthracite, and the average specific gravity is about 1.4.

Semi-Bituminous Coal

Semi-bituminous is a softer coal than anthracite or semi-anthracite, contains more volatile hydrocarbon, and will kindle more easily and burn more rapidly. It is usually free burning and owing to its high calorific, value, is very desirable for steam generation purposes.

Bituminous Coal

Bituminous coals are still softer than those already described and contain still more of the volatile hydrocarbons. The difference between semi-bituminous and bituminous coals is an important one, economically. The former have an average heating value per pound of combustible about 6 per cent higher than the latter, and they burn with much less smoke in ordinary furnaces. The distinctive characteristic of the bituminous coals is the emission of yellow flame and smoke when burning. In color they range from pitch black to dark brown, having a resinous luster in the most compact specimens, and a silky luster in such specimens as show traces of vegetable fiber. The specific gravity is ordinarily about 1.3.

Bituminous coals are either of the *caking* or *non-caking* variety. The former, when heated, fuse and swell in size; the latter burn freely, do not fuse, and are commonly known as *free-burning* coals. Caking coals are rich in volatile hydrocarbons, and are valuable in gas manufacture.

Table 2. Typical Analyses of Various Types of Fuel

Kind of Coal	Fixed Carbon Per Cent	Volatile Matter Per Cent	Moisture Per Cent	Ash Per Cent	Heat Value B.t.u. per Pound as Fired
Anthracite	82.6	3.7	3.2	10.5	12,840
Semi-Anthracite	83.3	9.4	1.3	6.0	13,920
Coke	81.7	2.8	5.7	9.8	12,050
Semi-Bituminous	73.2	18.7	1.2	6.9	14,370
Bituminous	48.4	36.3	6.7	8.6	12,200
Lignite	28.6	31.2	31.8	8.4	7,730

Lignite

Organic matter in the earlier stages of its conversion into coal is known as lignite and includes all varieties which are intermediate between peat and coal of the older formation. The specific gravity of lignite is low, being 1.2 to 1.23, and when freshly mined it may contain as high as 50 per cent of moisture. Its appearance varies from light brown, showing a distinctly woody structure in the poorer varieties, to black, with a pitchy luster resembling hard coal, in the best varieties. It is non-caking and burns with a bright but slightly smoky flame with moderate heat. It is easily broken, will not withstand much handling in transportation, and if exposed to the weather will disintegrate rapidly, which will increase the difficulty of burning it.

Its composition varies over wide limits. The ash may run as low as 1 per cent and as high as 50 per cent. Its high content of moisture and the large quantity of air necessary for its combustion cause large stack losses. Lignite is distinctly a *low-grade* fuel, and it is used almost entirely in the districts where it is mined, because of its cheapness.

Coke

Coke is a porous product, consisting almost entirely of carbon remaining after certain manufacturing processes have distilled off the hydrocarbon gases of the fuel used. Coke is produced (1) from gas coal distilled in gas retorts; (2) from gas or ordinary bituminous coals burned in special furnaces called coke ovens; and (3) from petroleum, by carrying the distillation of the residuum to a red heat.

Coke is a *smokeless* fuel. It absorbs moisture readily from the atmosphere and if not kept under cover its moisture content may be as much as 20 per cent of its own weight.

Gas-house coke is generally softer and more porous than oven coke, ignites more readily, and requires less draft for its combustion.

The *heat values* of coke range from 12,500 B.t.u. per pound to 13,500 B.t.u., depending on the ash content, which may vary from 5 to 10 per cent.

COMBUSTION OF COAL

The combustion of coal is the process of combining oxygen of the air with the carbon of the coal. In order to obtain perfect combustion, a definite amount of air is required for each pound of coal burned. The prime requirements for complete combustion are the combination of these elements in correct proportions and the thorough mixing of them in a zone of proper temperature.

A *deficiency* of oxygen or of air supply causes the formation of CO (carbon monoxide), which is incompletely burned carbon and which is evident by the soot and smoke.

An *excess* of air absorbs heat from the products of combustion and carries it out of the chimney as waste.

Air Required

The theoretical amount of air required per pound of fuel for perfect combustion is dependent upon the analysis of the fuel; however, for practical purposes the air supply required for different grades of fuel may roughly be taken as follows:

POUNDS OF AIR PER POUND OF FUEL AS FIRED

ANTHRACITE	COKE	SEMI-BITUMINOUS	BITUMINOUS	LIGNITE
9.6	11.2	11.2	10.3	6.2

An excess of about 50 per cent over the theoretical amount is considered good practice under usual operating conditions.

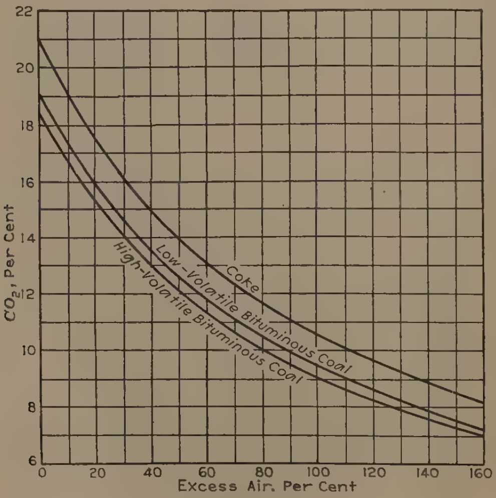


FIG. 1. RELATION BETWEEN CO$_2$ AND EXCESS AIR IN GASES OF COMBUSTION

The amount of excess air, based upon the laws of combustion, can be determined by its relation to the percentage of CO$_2$ (carbon dioxide) in the products of combustion. This relationship is shown by the curves (Fig. 1) for high and low volatile coals and for coke.

Combustion of Anthracite Coal

An anthracite coal fire should never be poked, as this serves to bring ash to the surface of the fuel bed, where it melts into clinker.

Grate size anthracite coal is suitable for large grates and for a fuel depth of 20 in. or more. The air spaces are large; the amount of surface in contact with the air is small, and consequently combustion is slow. Lumps of rock or slate, being large, may cause trouble in shaking the grate. On grates 25 in. and under, the fire is likely to go out easily with this fuel, unless mixed with small size coal for reducing the air spaces.

Egg size is suitable for large firepots (grates 25 in. and over) if the fuel can be fired at least 20 in. deep. The air spaces between the pieces of coal are large and normal combustion is slower than with the next smaller size coal. Pieces of rock and slate sometimes may be large enough to cause some trouble in shaking the grate. For best results this coal should be fired deep. The grate should be shaken before every firing.

Stove size coal is the popular size of anthracite fuel for most boilers and furnaces used for heating buildings. It is small enough to burn well on 17 in. grates, but large enough so that the draft loss through the fuel bed is not too great. Practically the only instructions needed for burning this type of fuel are:

The grate should be shaken before each firing; the fire should never be poked from the top; the fuel should be fired deeply and uniformly.

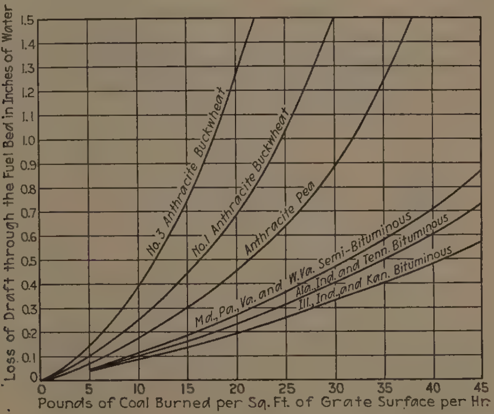


FIG. 2. DRAFT REQUIRED AT DIFFERENT RATES OF COMBUSTION FOR VARIOUS KINDS OF COAL

Chestnut size coal is in demand for firepots up to 20 in. in diameter, especially those in which the fuel cannot be fired over 18 in. deep. The percentage of ash is higher than in stove coal, but the pieces of rock and slate are small and do not interfere with the shaking of the grates.

Pea size coal is often an economical fuel to burn. It is relatively low in price. When fired carefully, pea coal can be burned on standard grates. It is well to have a small amount of a larger fuel on hand when building new fires, or when filling holes in the fuel bed. Care should be taken to shake the grates only until the first bright coals begin to fall through the grates. The fuel bed, after a new fire has been built, should be increased in thickness by the addition of small charges until at least level with the sill of the fire door. This keeps a bed of ignited coal in readiness against the time when a sudden demand for heat shall be made on the heater. When firing, the bright fuel should either be pulled forward or pushed to the back of the firepot, leaving a hollow in which to throw the fresh fuel and leaving a portion of the glowing coal exposed, to ignite the gases rising from the fuel; otherwise a gas explosion may occur.

Pea size coal requires a strong draft and therefore the best results generally will be obtained by keeping the choke damper open, the cold-air check closed and by controlling the fire with the air-inlet damper only.

Buckwheat size coal requires much the same attention as pea size coal, except that the smaller size of the fuel makes it more difficult to burn on ordinary grates. Even greater care must be taken in shaking the grates than with pea coal on account of the danger of the fuel falling through the grate. A good draft is required and consequently the fire is best controlled by the air-inlet damper only. Where frequent attention can be given and where there is not a big heat demand, this fuel is frequently burned without the aid of any special equipment.

In general it will be found more satisfactory with buckwheat coal to maintain a uniform heat output and consequently to keep the system warm all the time, rather than to allow the system to cool off at times and then to attempt to burn the fuel at a high rate while warming up. A uniform low fire will minimize the clinker formation and keep the clinker in an easily broken up condition so that it readily can be shaken through the grate.

Forced draft and special grates or retorts frequently are used with this fuel for best results.

Combustion of Bituminous Coal

Bituminous coal should never be fired over the entire fuel bed at one time. A portion of the glowing fuel should always be left exposed to ignite the gases leaving the fresh charge.

Air should be admitted over the fire through a special secondary air device, or through a slide in the fire door or by opening the fire door slightly. If the quantity of air admitted is too great the gases will be cooled below the ignition temperature and will fail to burn. The fireman can judge the quantity of air to admit by noting when the air supplied is just sufficient to make the gases burn rapidly and smokelessly above the fuel bed.

The red fuel in the firebox, before firing, excepting only a shallow layer of coke on the grate, should be pushed to one side or forward or backward to form a hollow in which to throw the fresh fuel. (Some manufacturers recommend that all red fuel be pushed to the rear of the firebox and that the fresh fuel be fired directly on the grate and allowed to ignite from the top. The object of this is to reduce the early rapid distillation of gases and to reduce the quantity of secondary air required for smokeless combustion).

It is well to have the bright fuel in the firebox so placed that the gases from the freshly fired fuel, mixed with the air over the fuel bed, pass over the bed of bright fuel on the way to the flues. The bed of bright fuel then supplies the heat to raise the mixture of air and gas to the ignition temperature, thereby causing the gaseous matter to burn and preventing the formation of smoke.

The fuel bed should be carried as deep as the size of fuel and the available draft permit, in order to have as much coked fuel as possible for pushing to the rear of the firebox at the time of firing. A deep fuel bed obtains the longest firing intervals.

If the coal is of the caking kind the fresh charge will fuse into one solid mass which can be broken up with the stoking bar and leveled from 20 min. to one hour after firing, depending on the temperature of the firebox. Care should be exercised when stoking not to bring the bar up to the surface of the fuel as this will tend to bring ash into the high temperature zone at the top of the fire, where it will melt and form clinker. The stoking bar should be kept as near the grate as possible and should be raised only enough to break up the fuel. With fuels requiring stoking it may not be necessary to shake the grates, as the ash is usually dislodged during stoking.

The output obtained from any heater with bituminous coal will usually exceed that obtainable with anthracite, since soft coal burns more rapidly than hard coal and with less draft. Soft coal, however, will require frequent attention to the fuel bed, because it burns unevenly, even though the fuel bed may be level, forming holes in the fire which admit too much air, chilling the gases over the fuel bed and reducing the available draft.

Combustion of Semi-Bituminous Coal

Semi-bituminous coal is fired like bituminous coal and because of its caking characteristics requires practically the same attention.

Combustion of Coke

Coke is a very desirable fuel and usually will give satisfaction as soon as the user learns how to control the fire. Coke ignites and burns very rapidly with less draft than anthracite coal. In order to control the air admitted to the fuel it is very important that all openings or leaks into the ashpit be closed tightly. A coke fire responds more rapidly than an anthracite fire to the opening of the dampers. This is an advantage in warming up the system, but it also makes it necessary to watch the dampers more closely in order to prevent the fire from burning too rapidly. A deep fuel bed always should be maintained when burning coke. The grates should be shaken only slightly in mild weather and should only be shaken until the first red particles drop from the grates in cold weather. Since coke weighs only about half as much as anthracite coal per cubic foot, and therefore only about half as much can be put in the firepot, it will be necessary to fire oftener; but during the greater part of the heating season this will not be an item of importance. The best size of coke for general use is that which passes over a 1 in. screen and through a 1½ in. screen; for small firepots where the fuel depth is not over 20 in. For large firepots where the fuel can be fired over 20 in. deep, coke which passes over a 1 in. screen and through a 3 in. screen will be most satisfactory. Large sizes of coke should be either mixed with fine sizes or should be broken up before using.

Draft Required for Burning Coal

The amount of draft required to effect a given rate of combustion is dependent upon the following factors:

1. Character and condition of fuel.
2. Combustion rate, or amount of fuel burned per square foot of grate area per hour.
3. Thickness of fuel bed.

Insufficient draft will cause the coal to accumulate on the grates, the result being a dead and smoky fire and consequently poor combustion.

The curves (Fig. 2) give the intensity of draft necessary properly to burn several kinds of coal at various rates of combustion.

Secondary Air

Secondary or auxiliary air (air supplied over the fuel bed) should be provided whenever it increases the temperature in the firebox. Soon after each firing, considerable combustible gas rises from any fuel, and enough air for its combustion cannot be supplied through the fuel bed, but must be provided by other means; usually through a slide damper in the fire door. The amount of secondary air required for high volatile coals is often as much as 50 per cent of the total air required for combustion. Too much secondary air will cool the gases below the ignition point, and prove harmful rather than beneficial.

The amount of secondary air required depends on so many variables that it is impossible to establish a set of rules to fit all cases.

The following suggestions will be helpful:

1. In cold weather, with high combustion rates, the secondary air damper should be half open all the time.
2. In very mild weather, with a very low combustion rate, the secondary air damper should be closed all the time.
3. For temperatures between very mild and very cold, the secondary air damper should be in an intermediate position.
4. For ordinary house operation, secondary air is needed after each firing for about one hour.

Secondary air, when used with bituminous coal, serves the purpose of preventing smoke as well as increasing the efficiency by burning the gas escaping from the fuel bed. As a guide to the amount of secondary air required, it may be remembered that the user should supply just enough secondary air to eliminate the smoke.

Preparing for Pick-Up Load

The period of maximum heat demand should be anticipated in order that ash and clinker can be removed and enough fuel fired to have a deep fuel bed well ignited at the beginning of this period. This is even more important with anthracite than with bituminous, due to the slower ignition of the former.

In extremely cold weather, which occurs only during a few days per season, it is advisable, if the reserve output of the heater is small, to keep the room temperature normal continuously, to eliminate the peak demand due to pick-up temperature.

HAND FIRING

Hand firing is the oldest and the most widely used method of burning coal for heating purposes. To keep the fuel bed in proper condition where hand firing is used, the following general rules should be observed:

1. Remove ash from fuel bed by shaking the grates whenever fresh fuel is fired. This removes ash from the fire, enables the air to reach the fuel and does away with the formation of clinker (which is melted ash).

2. Supply the boiler with a deep bed of fuel. Nothing is gained by attempting to fire a small amount of fuel. A deep bed of fuel secures the most economical results.

3. Remove ash from ashpit at least once daily. Never allow ash to accumulate up to the grates. If the ash prevents the air from passing through, the grate bars will burn out and much clinker trouble will be experienced.

Hand-Fired Boilers

The principal requirements for a hand-fired furnace are that it shall have enough grate area and combustion space. The proper proportion of these features generally will give ample fuel space, which always is desirable for heating boilers.

The amount of grate area required is dependent upon the desired combustion rate, recommendations for which are given for various kinds of coal in Table 1, Chapter 15.

The furnace volume is influenced by the kind of coal used. Bituminous coals on account of their long-flaming characteristic require more space in which completely to burn the gases of combustion than do the coals low in volatile matter. For burning high volatile coals provision should be made for mixing the combustible gases thoroughly so that combustion is complete before the gases come in contact with the relatively cool heating surfaces. An abrupt change in the direction of flow tends to mix more thoroughly the gases of combustion.

Hand-fired furnaces may be classed as follows: Up-draft, smokeless arch (inverted bridge wall) and down-draft furnaces.

The *up-draft* furnace is the usual type provided in heating boilers and is used generally with all kinds of coal. While it is suitable for use with anthracite, coke, and semi-bituminous coal, the up-draft furnace is decidedly inadequate for burning bituminous coals from a standpoint of economy.

Due to the difficulty in controlling properly and mixing intimately the air supply with the gases of combustion, combustion usually is incomplete within the up-draft furnace. Consequently, high losses occur due to unburned carbon in the chimney gases and the smoke nuisance is a constant annoyance. There are many more or less efficient schemes for introducing heated air above the fire in up-draft boilers. These all when well adjusted, reduce smoke.

The *smokeless arch* is an inverted baffle placed in the ordinary up-draft furnace toward the rear. Its purpose is to aid in mixing the gases of combustion.

In the operation of a furnace which has an arch, a heavy bed of coked fuel is maintained, which at the time of firing is pushed toward the rear of the furnace while the fresh fuel charge is added in front of it. The volatile matter distilled from the fresh fuel and a secondary air supply above the fire are deflected underneath the arch so that mixing, ignition, and combustion occur in the hot zone over the bed of coke.

Admission of the secondary air supply is usually either through registers in the fire doors or through ports located in the sides of the furnace or through a combination of both. With the side port arrangement the air is carried through the hollow arch where it may become heated and from which it is delivered into the combustion chamber through a series of openings along the bottom or rear side of the arch.

By aid of the smokeless arch, high volatile coals can be burned with practically no smoke at moderate rates of combustion.

The *down-draft* furnace (originally known as the Hawley down-draft furnace) consists of an upper grate of water tubes located above the usual rocking grate. The draft draws down through the upper grate and up through the lower grate. Coal is fired above the fuel bed on the upper grate and after the ash and some coke have been worked down on the lower grate a lively fire is maintained on both grates. The volatile gases pass down through the upper fuel bed and become highly heated as they meet in the combustion chamber between the grates, with the heated excess air from the lower fuel bed.

This type of furnace has proved successful for burning bituminous coal with high efficiency and without smoke.

MECHANICAL STOKER FIRING

Mechanical stokers have long been considered essential standard equipment for all major heating installations. They make it possible to burn coal at a high efficiency without smoke. Within recent years the smaller sizes of mechanical stokers have been developed to a remarkable extent, and it is now possible to achieve results with the small sizes which are comparable to those obtained in the large plants.

Advantages of Stoker Firing

With mechanical stoker firing there are a number of advantages over hand firing for burning bituminous coal. A good mechanical stoker installation will result in a saving of from 15 to 35 per cent of the fuel cost. It may save labor cost. Stokers will burn nut, pea and slack screenings, which are difficult if not impracticable for hand firing, and which can be purchased generally at a lower price than the coarser sizes of coal usually required for hand firing. The stoker, feeding coal continuously, without the uncontrolled blasts of excess air inherent to hand firing, will give more uniform combustion results than will hand firing, and will provide smokeless operation. For this reason alone, to abate the smoke nuisance, stokers are being specified for heating plants in many of the larger cities by smoke controlling departments. With mechanical stokers, automatic control is provided to give uniform steam pressure or temperature, the work and attention of the fireman is reduced and usually he can direct more attention to other duties. Frequently with old plants a lower capital charge and a higher return can be secured by installing stokers to increase the output of the old boilers rather than to purchase additional hand-fired boilers.

Types of Stokers

Stokers may be classified roughly as of the overfeed type and the underfeed type.

The *overfeed stoker* principally is used with natural draft. Although it feeds the coal automatically and continuously and gives improved results over hand firing, it requires heat-storing masonry arches to give proper combustion and must have large combustion space and good draft to draw the air through the fuel bed. There is some evidence that the natural draft overfeed type of stoker is less flexible and adaptable in heating boilers than the forced draft underfeed stoker.

The *underfeed stoker*, as the name implies, feeds the coal underneath the fuel bed. The hot fire is on top of the bed and the fresh fuel as it is pushed up underneath the fire is ignited thoroughly.

The gases from the igniting coal, being forced through the hot fire above the coal, have all volatile matter burned completely and no unburned carbon leaves the furnace. In heating boilers the combustion chamber often is water jacketed and this directly exposed surface plays a very important part in the heat transfer to the boiler, so that the underfeed stoker, with its hot coals on top of the fuel bed, is particularly well suited to heating boilers.

With this type of stoker a forced draft fan is used for driving the air through the fuel bed, and the chimney is required only to draw the gases through the boiler.

With an underfeed stoker, due to thorough ignition, the gases burn with a short flame and it is possible to achieve smokeless combustion even where the combustion space is limited.

Underfeed stokers are made with multiple retorts and with single retorts. The *multiple retort*, rear cleaning types are used in large plants where great quantities of coal are burned. Smaller boilers up to about 30,000 sq. ft. rating in size, generally are best adapted to the *single retort type*. The coal is fed into the single retort stoker either by a screw conveyor or by a reciprocating ram.

The screw type of conveyor is very old in stoker practice but has been revived recently and gives good results for small retorts.

The larger retorts using a screw conveyor, experience some difficulty in getting uniform distribution of the coal sideways and longitudinally. With a reciprocating ram, however, equal distribution may be obtained to both sides of the furnace. A distributing moving bar in the bottom of the retort of a ram type stoker makes it possible to control the distribution of the fuel longitudinally.

It is obvious that uniform distribution of the fuel is essential in any underfeed stoker.

Single retort stokers are made in the dead plate type and in the side dumping grate type. With the *dead plate* arrangement the hot ashes must be pulled out through the fire door, whereas with the *dumping grate* type the ashes are dropped into the ashpit and may be removed at the convenience of the fireman. This arrangement makes it possible to clean the fires much more quickly and easily than with the dead plate type and dust and hot gases in the boiler room may be reduced.

Single retort underfeed stokers are furnished complete with forced draft fan, electric motor and air duct all built-in as a unit as shown in Fig. 3. This makes a compact and economical arrangement which is particularly well suited for heating plants. Each boiler is a self-contained independent unit. In plants of two or more boilers there is a saving in electric power with unit stokers over the cost for a central fan system, particularly when only one boiler is operated for light load conditions.

The underfeed stoker particularly is suited for burning high volatile coals such as bituminous, semi-bituminous, sub-bituminous and the lignites. With low grades of fuel it is of course necessary to install a larger stoker than the size which is necessary to obtain the same capacity with the higher grades of fuel, such as are mined in the Eastern States. The size of coal preferred usually for underfeed forced draft stokers is 1¼ in. screenings, consisting of approximately equal portions of nut, pea and slack.

With the coking fuels a greater percentage of slack can be burned than with non-coking coals, but with the non-coking coals at least one-third of the screenings should be nut size. With the non-coking coal, such as Illinois and Indiana mines produce, too much slack makes the fuel bed dense and it is more difficult to force the air through it. The coarse sizes of coal such as lump and mine run are usually sold at a higher price per ton than screenings, and are more difficult to feed into the stoker. The coarser sizes of coal will not give as uniform a fuel bed nor as good combustion results as the screenings.

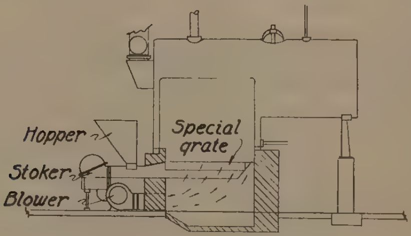


FIG. 3. A UNIT UNDERFEED STOKER

A *horizontal feed* stoker for service with small boilers has recently been developed. This type of stoker has some stationary and some movable grate sections, each made up of a number of small bars. These sections are inclined so that the movement of the fuel bed is forward and down the hill, though gravity plays no part in the advancement of the fuel.

Electric Motors and Controls

Constant speed motors are used on some of the smaller mechanical stoker installations. The fan and the stoker are operated at full speed and the motor is stopped and started according to the load demand. With this arrangement a magnetic switch is used and is controlled for automatic operation by a regulator which may be influenced by the steam pressure, the water temperature or by a thermostat set to maintain a certain room temperature in the building which is being heated.

With polyphase alternating current or with direct current, variable speed motors are much more desirable than constant speed motors. They are furnished with speed regulators and magnetic switches providing overload and underload protection. The automatic control may be provided to start and stop the motor from an adjustable automatic regulator controlled to maintain any desired steam pressure, water temperature or room temperature. With the variable speed motor high speed is used for heavy load conditions and may be reduced automatically for light load conditions. The best combustion results thus are obtained and longer life for the stoker mechanism and more quiet operation of the fan is achieved.

Variable speed motors also may be controlled from hydraulically operated compensating automatic regulators. With this arrangement the speed of the motor is varied gradually according to the load demand. The speed regulator may be interlocked with the magnetic switch so that the automatic regulator will also start and stop the motor for extreme variations in the load. This hydraulic-electric regulation usually is superior to the start and stop type of control, but naturally is somewhat more costly.

Selection of Stokers

In recent years there have been put on the market a large number of different makes of stokers, and competent advice and judgment are required in selecting the equipment. Usually each plant has its own peculiar problems and requires study by a capable combustion engineer. In general the necessity for adequate height between grate and boiler surface and of combustion space within the firebox must be emphasized. It is especially important, when installing any mechanical stoker, that adequate instruments shall be furnished for indicating to the operator the exact conditions as to draft and air admixture, since without these the operation of the boiler may be exceedingly inefficient.

Pulverized Fuel

There are a number of very successful installations of pulverized coal burning plants in heating boilers, especially in the Central West. These are of the unit type, in which the pulverized coal is delivered immediately after grinding, with the proper amount of preheated air, into the furnace. With this apparatus, where the necessary furnace volume is obtainable, exceedingly high efficiencies without any smoke or fly ash, can be obtained. Each year witnesses improvement and simplification of the apparatus and a gain in the skill in designing and in operating pulverized fuel burning equipment. High ratings are obtainable and one of the great advantages of pulverized coal equipment is the fact that a boiler can be heated and made to deliver high output in an almost unbelievably short time.

With unit pulverizing machines especially there is apparently no more danger of coal dust explosions than there is with other types of coal handling machinery.

STORAGE SPACE FOR COAL

The storage space required for coal or coke is dependent upon the frequency of fuel purchases during the heating season, as well as upon the rate at which the fuel is burned.

In general, the size of the storage space can be determined on the basis of burning 3½ tons of coal or coke per heating season per 100 sq. ft.

of attached equivalent radiation, based on a heat emission of 240 B.t.u. per square foot.

Anthracite coal weighs approximately 52.5 lb. per cubic foot; bituminous, 45 lb. per cubic foot; and coke, 28 lb. per cubic foot.

HEATING COSTS WITH COAL

In most cases, heating costs with coal are lower than the costs with gas, oil or electricity, even though the efficiency of combustion usually is less than that with gas and oil. At prices of today the cost of coal ranges from about 40 cents to $1.20 per 1,000,000 B.t.u., giving proper consideration to efficiencies. For comparisons with the cost of other heat sources, see Chapters 11, 12 and 13.

CHAPTER 11

HEATING BY GAS

Original and Conversion Installations; Gas Fired Boilers and Furnaces; Space Heaters; Combustion and Heat Values; Installation Data; Costs to Operate.

THE desirability of gas for heating purposes is quite generally recognized, but the use of this fuel has been limited in many cases because of its higher cost. Hence, one of the problems peculiar to the use of gas for heating purposes is that of fuel utilization. Gas is a fuel with a high thermal value and is easy to handle and control. This ease of control makes possible extreme economy, and gas-burning appliances should, therefore, be designed and selected to take full advantage of this potential economy.

Determination on the part of gas companies that building heating is a desirable load to have on their lines has led to an increasing number of such corporations granting materially reduced rates for gas used for heating purposes. The communities in which reduced rates for heating purposes have been granted are of a widely diversified character as to size, climate, geographical situation and industries. In natural gas territories, the rates, while showing a tendency to increase, are still such that gas is a cheap fuel for any purpose. An increasing demand for efficient gas-burning appliances always follows an increase in gas cost.

The corporations from which gas is purchased usually display a continued interest in the up-keep and efficient operation of the fuel-burning appliance. A large proportion of the gas-burning heating appliances are installed and distributed through gas companies. The gas company then stands ready to see that the purchaser of the appliance enjoys uninterrupted and efficient service from it. A notable development of comparatively recent date is the offering of gas-burning boilers designed for large-scale heating.

CALORIFIC VALUE AND EFFICIENCY

When gas is burned a large amount of water vapor is produced as one of the products of combustion. This ordinarily escapes up the chimney, carrying away with it a certain amount of heat. However, when the heat value of gas is determined in an ordinary calorimeter, this water vapor is condensed and the latent heat of vaporization that is given up during the condensation is reported as a portion of the heat value of the gas. The heat value so determined is termed the "Higher Heat Value" and this is what is ordinarily meant when the heat value of gas is specified. The heat that is reclaimed by the condensation of the water vapor amounts to about 10 per cent of the total heat value. It is practically impossible to utilize the entire higher heat value of the gas in any house-heating appliance, because to do so it would be necessary to cool the products of combustion down below their dew-point, which is ordinarily in the neighborhood of 130 deg. A stack temperature of 130 deg. is not sufficient to produce a good draft under actual installation conditions.

The heat balance of a gas-burning heating boiler or furnace, therefore, includes the following items:

Heat in the dry flue gas.
Heat in the water vapor.
Heat loss due to incomplete combustion.
Heat loss through radiation.
Heat absorbed by the water or air in the boiler or furnace.

Table 1 shows the maximum theoretical efficiencies when burning a typical manufactured gas with various stack temperatures. These are based on the higher heat value of the gas, and do not include any correction for radiation from the boiler covering. Radiation will reduce these efficiencies as much as 5 per cent, depending on the insulating properties of the covering. The gas is assumed to be burned with 35 per cent excess air and has the following composition:

CO_2	8.6	per cent
H_2	52.5	" "
CH_4	31.6	" "
C_2H_4	1.1	" "
C_6H_6	1.1	" "
O_2	0.1	" "
CO_2	1.5	" "
N_2	3.5	" "
	100.0	per cent

Heat value per cubic foot at 60 deg. fahr. and 30 in. hg., 535 B.t.u.
Specific gravity 0.58 (air = 1)
Air Temperature 60 deg. fahr.
Atmospheric moisture neglected.

TABLE 1. PRODUCTS OF COMBUSTION AND THEORETICAL EFFICIENCIES WITH A TYPICAL MANUFACTURED GAS

Stack Temperature (deg. fahr.)	250	275	300	350
Heat in Dry Flue Gas above 60 deg. (%)	3.57	4.05	4.52	5.48
Heat in Water Vapor above 60 deg. (%)	9.13	9.22	9.30	9.47
Heat absorbed by boiler, or efficiency (%)	87.30	86.73	86.18	85.05
Radiation (not calculated)	0	0	0	0
	100.00	100.00	100.00	100.00

Flue Gas Analysis

CO_2 11.18% O_2 5.63% N_2 83.19%

It will be seen from Table 1 that the maximum attainable efficiency under practical operating conditions, which include the necessity of having a stack temperature sufficiently high to insure a good draft, and with a normal radiation loss, is approximately 80 per cent.

AIR FOR COMBUSTION

Most gas appliances consume the gas with a blue or Bunsen flame, although some room heaters use a luminous or yellow flame. Bunsen flames and luminous flames differ in the way in which the air necessary for combustion is supplied. Bunsen type burners are provided with an external mixer, in which a portion of the air is mixed with the gas previous to ignition. This is called *primary air*. The aspirating effect of the jet of the mixture issuing from the burner ports, and the chimney effect of the gas passages above, draw currents of air past the flame and into it, in sufficient quantity to cause complete combustion. This is known as *secondary air*. In order for combustion to be complete and for the products to be free of carbon monoxide, it is necessary that heating surfaces be sufficiently high above the burner to prevent the pale blue inner cone, which is a characteristic part of a Bunsen flame, from striking any cold heating surfaces. A yellow tip on the flame indicates insufficient primary air and is corrected by opening the adjustable air shutters.

Some room heaters which consume gas in very small amounts use the luminous flame. A luminous flame is limited in its application to appliances burning small amounts of gas. No part of a luminous flame can be allowed to touch any cold surface, as this will result in incomplete combustion with the formation of soot and carbon monoxide.

Table 2 shows the heat values of a cubic foot of each of three common varieties of gas, together with the theoretical air requirements and the air requirements with 50 per cent excess. In practice excess air must be admitted to the fire in order to insure complete combustion.

Table 2. Volume of Air Required for Combustion of Different Gases

Gas	B.t.u. per Cubic Foot	Theoretical Air per Foot of Gas Cu. Ft.	Actual Air with 50 Per Cent Excess Cu. Ft.
Natural Gas	1131	10.70	16.05
Coke Oven Gas	560	4.78	7.17
Mixed Coke Oven and Water Gas	537	5.03	7.55

In designing and installing gas-burning equipment, particularly where large amounts of gas are to be consumed, it is important that provision be made for the easy access of sufficient air to support combustion and to provide boiler room ventilation. Very little motive force exists to draw air into the boiler room. Therefore, the opening through which it enters must be large enough to keep the velocity to a very low value.

FUEL COSTS WITH GAS

In comparing the cost of gas with that of other fuels, a common basis should be used. This is usually taken as the cost per 1,000,000 B.t.u. and for gas involves consideration of the calorific value of the fuel, the overall efficiency and the average gas rate, which should include the demand rate as well as the commodity rate.

The chart (Fig. 1) can be used for estimating the cost per 1,000,000 B.t.u. for both manufactured and natural gas for various efficiencies and average gas rates. This chart is based on a heat content of 535 B.t.u. per cubic foot for manufactured gas and 1,000 B.t.u. for natural gas.

By reference to the Chapters on Heating by Coal, Heating by Oil and Heating by Electricity, a comparison can be made as to heating costs with these other heating media.

GAS REQUIREMENTS OF BUILDINGS

Residences

It is a fact, based upon observation, that the user of a gas-fired central-heating appliance in a residence uses more heat during the course of a year than he does when depending upon solid fuel. The extreme ease of starting and operating a gas-burning appliance results in the pilot light being lighted on the first cool day of the season. Thereafter the system generally operates entirely under thermostatic control. It is in operation on many days when very little heat is required, days when it would be impracticable or inconvenient to keep a coal-fire going. On many cold days the gas unit is kept operating continuously at maximum capacity, so that the premises are never permitted to cool below the temperature ordinarily maintained.

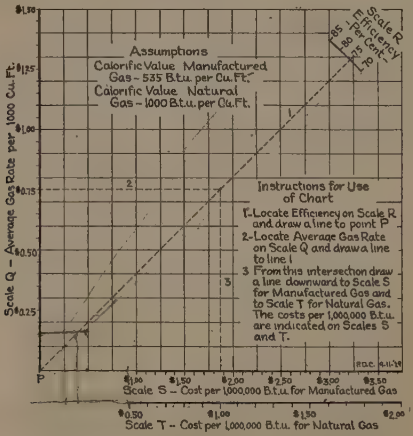


FIG. 1. CHART FOR ESTIMATING THE COST PER 1,000,000 B.T.U. FOR MANUFACTURED AND NATURAL GAS FOR VARIOUS EFFICIENCIES AND AVERAGE GAS RATES

For a given building maintained at a given temperature, the curve of gas consumption follows the curve of outdoor temperature very closely. The efficiency of the appliance is almost independent of the load, so that the gas consumption is almost proportional to the temperature difference. This property of the gas-burning heating plant makes it relatively easy to estimate the heating costs, once the basic relations have been determined.

In making an estimate of the gas that will be consumed by a gas-fired heating installation during the average heating season, two variables must be taken into account. The first of these is the size of the heating system, usually expressed in terms of square feet of direct cast iron radiation. The other one is the duration and intensity of the heating season. This is easiest expressed in terms of degree-days. A definition of the term *degree-day* may be in order. It has been found that people who use gas under automatic control for heating their homes, seem to require heat on those days when the mean temperature drops below 65 deg. Thus 65 deg. is taken as the datum line from which to measure the number of degree-days in a month or any other given period. The degree-day can be defined as a day on which the mean temperature is one degree below 65 deg., or 64 deg. Therefore, if the mean temperature for each of the 30 days in a month was 64 deg., we would have accumulated 30 degree-days in that month. By summing up the degree-days for the different days of the heating season, we get the total degree-days for the entire heating season. Studies of weather reports have established the number of degree-days for over 300 cities in the United States and Canada, and it is easy to calculate the heating demands for a particular city. Gas consumption for a given type and size of installation will always be proportional to the number of degree-days in the heating season for the locality in question. Table 3 gives values of degree-days for representative cities.

By averaging the records of a large number of gas-boiler installations, operating under thermostatic control, with a reduced temperature at night, the following equations have been derived:

$$\text{For Steam } G = \frac{110 \times R \times D}{H} \qquad \text{For Water } G = \frac{64 \times R \times D}{H}$$

where

G = cubic feet of gas per season.
R = square feet of direct cast iron radiation (as calculated)
D = degree-days per season.
H = B.t.u. (gross) per cubic foot of gas.

Example: To estimate the gas consumption for the average heating season for a 200 sq. ft. steam heating system in Chicago.

From Table 3 it is found that the average heating season in Chicago has 6,007 degree-days. The gross heat value of the gas supplied to that city is 535 B.t.u. per cubic foot. Substituting in the equation:

$$G = \frac{110 \times 200 \times 6{,}007}{535} = 247{,}017 \text{ cu. ft.}$$

Observe in the equation that the calculated theoretical amount of radiation is to be used. By this is meant the actual amount of radiation that is required, as determined by accepted methods of heat-loss calculations. Over-radiation will not materially affect the gas consumption, while under-radiation will merely reflect itself in inability to heat in extremely cold weather. The amount of gas consumed for heating a residence during any given heating season may vary decidedly from an estimate according to the method outlined, but the variation will be in almost direct proportion to the difference between the actual degree-days for the season in question and the average degree-days as shown in Table 3.

Large Buildings

In comparing the true cost of heating a large building of a commercial nature with gas, as opposed to other fuels, there are a number of items

TABLE 3. DEGREE-DAYS FOR CITIES IN THE UNITED STATES AND CANADA

COL. *A*	COL. *B*	COL. *C*	COL. *A*	COL. *B*	COL. *C*
State	City	Degree-Days	State	City	Degree-Days
Ala.	Mobile	1,439	Nev.	Tonapah	6,069
	Birmingham	2,527		Winnemucca	6,266
Ariz.	Phoenix	1,446	N. H.	Concord	7,335
	Flagstaff	10,913	N. J.	Atlantic City	5,250
Ark.	Hot Springs	2,665	N. Y.	Albany	6,542
	Little Rock	2,861		Buffalo	6,750
Cal.	San Francisco	3,450		New York	5,303
	Los Angeles	1,517	N. M.	Sante Fe	6,064
Colo.	Denver	5,880	N. C.	Raleigh	3,287
	Grand Junction	5,570		Wilmington	2,493
Conn.	New Haven	6,039	N. D.	Bismark	8,498
D. C.	Washington	4,562		Grand Forks	9,724
Fla.	Jacksonville	1,080	Ohio	Cleveland	6,096
Ga.	Atlanta	2,880		Columbus	5,426
	Savannah	1,517	Okla.	Oklahoma City	3,827
Idaho	Lewiston	4,924	Ore.	Portland	4,449
	Pocatello	6,459		Salem	4,629
Ill.	Chicago	6,007	Pa.	Philadelphia	4,950
	Springfield	5,495		Pittsburgh	5,327
Ind.	Indianapolis	5,331	R. I.	Providence	6,111
	Evansville	3,355	S. C.	Charleston	1,770
Iowa	Dubuque	6,744		Columbus	2,600
	Des Moines	6,464	S. D.	Pierre	7,213
Kans.	Topeka	5,282		Sioux Falls	7,683
	Dodge City	5,035	Tenn.	Knoxville	3,517
Ky.	Louisville	4,366		Nashville	3,550
La.	New Orleans	1,044	Texas	El Paso	1,912
	Shreveport	2,097		Galveston	1,050
Me.	Eastport	8,676		San Antonio	1,362
	Portland	7,267	Utah	Salt Lake City	5,358
Md.	Baltimore	4,591		Logan	6,750
Mass.	Boston	6,055	Vt.	Burlington	8,123
Mich.	Alpena	8,319	Va.	Richmond	3,789
	Detroit	6,202		Lynchburg	3,849
	Marquette	8,866		Danville	3,316
Minn.	Duluth	9,650	Wash.	Seattle	5,156
	Minneapolis	7,953		Spokane	6,085
Miss.	Jackson	1,920	W. Va.	Elkins	5,813
Mo.	St. Joseph	5,289		Parkersburg	4,884
	St. Louis	4,583	Wis.	Green Bay	8,201
	Springfield	4,650		La Crosse	7,309
Mont.	Billings	6,983		Milwaukee	7,366
	Havre	8,608	Wyo.	Sheridan	8,113
Nebr.	Lincoln	6,231		Cheyenne	7,360
	North Platte	6,479			

COL. *A*	COL. *B*	COL. *C*	COL. *A*	COL. *B*	COL. *C*
Province	City	Degree-Days	Province	City	Degree-Days
B. C.	Victoria	5,777	Ont.	Toronto	7,732
	Vancouver	5,976	Que.	Montreal	8,705
	Kamloops	6,724		Quebec	8,628
Alb.	Medicine Hat	8,152	N. B.	Frederickton	9,099
Sask.	Qu Appelle	11,261	N. S.	Yarmouth	7,694
Man.	Winnipeg	11,166	P.E. I.	Charlottetown	8,485
Ont.	Port Arthur	10,803			

that should be considered in addition to the bare fuel costs. Rental value of the floor space occupied by the boiler installation and of the space required for fuel and ash storage, may have a strong bearing on the true cost of heating. When gas is burned the added feature of cleanliness resulting from the elimination of coal delivery and ash removal may add materially to the attractiveness of the building. It is difficult to evaluate the reduced necessity for redecoration when gas is used, because the frequent changes in tenancy encountered in this class of building always necessitate redecoration. There are many cases however, where this factor has a tangible value.

TABLE 4. GAS REQUIREMENTS FOR LARGE BUILDINGS

STEAM RADIATION	B.T.U. PER SQUARE FOOT, PER DEGREE-DAY
1,000	114.5
2,000	110.0
3,000	107.0
4,000	105.0
5,000	104.0
6,000	102.0
7,000	100.5
8,000	99.0
9,000	97.5
10,000	96.0
11,000	94.5
12,000	92.7
13,000	91.0
14,000	89.5
15,000	88.0
20,000	80.5

The supervision of a gas-heated plant is reduced to a minimum. The methods of control produce a uniform temperature at all times, with the minimum requirements of making sure that the pilots are operating and that the temperature controls are set at the proper joint. It is often possible to eliminate on many engineers and coal-passers, substituting therefor about a half-hour's supervision of a building supervisor or porter. Gas companies generally provide necessary engineering attention to the installations, such as periodic inspections; which include cleaning, washing down and adjustment of controls and burners.

Gas-fired installations for heating larger buildings are controlled by the usual methods, or by the application of distinctive gas methods designed to prevent sudden large demands on the services at the instant when the boilers are called upon for heat. Where a battery of boilers is installed, magnetic valves bleeding gas from the tops of unbalanced snap-action diaphragm valves may be employed under the control of an intermittent timing device or of a conventional type of thermostat. By drilling the bleed orifice on each of the boilers of a different size, the boilers will come on at intervals, depending on the size of the bleed orifice. In this way the full demand is not allowed to come on the meters or gas service instantaneously and full-line pressure is available for each of the boilers as it starts. In the same way, when the boilers are shut down, the demand is taken off in steps, eliminating fluctuations in the service pressure.

The steam pressure controls on each one of a battery of several boilers may be set to cut off at different steam pressures. By this means, one boiler can be allowed to carry the base load and the other boilers can be allowed to come on at different pressure intervals and thus carry the peak-loads.

It has been found by analysis of a number of installations that the values given in Table 4 represent the gas requirements of large commercial building heating installations under thermostatic control, expressed in B.t.u.'s per square foot of steam radiation per degree-day.

These values can be converted into annual gas consumptions by the method outlined on a preceding page.

Figs. 2 and 3 graphically represent the number of cubic feet of gas per square foot of radiation for the heating season in any climate, the climate being expressed in degree-days. These figures are applicable to any heating condition in the United States. These charts give very close estimates when the radiation is proportioned to maintain a maximum inside temperature of 70 deg. and when that temperature is maintained.

The rate structures of many gas companies are so devised that additional uses of gas, such as hot-water supply, restaurant use and incineration are charged for at preferential rates, if the main load is for building heating.

INSULATION AND WEATHERSTRIPPING

If fuel had no value, there would be no object in reducing the heat losses of a building, at least from the standpoint of fuel economy.

On the other hand, the more costly a fuel, the greater the thickness of insulation required to economically heat a building. It is therefore important that the walls and roof of a building to be heated with gas, especially manufactured gas, be well insulated. The windows should also be equipped with weatherstripping and storm sash.

If the heat losses of a building to be heated by a more expensive fuel are reduced sufficiently, the building can be heated at no greater annual fuel cost than the same building could be heated with a cheaper fuel, if it were not insulated. In many cases the proper insulation of gas-heated buildings is an economic necessity, for without wall and roof insulation, weatherstripping and storm sash, the cost of heating would be exorbitant.

Conversions

During the period when gas heating was limited to those localities where a cheap supply of natural gas was available, practically all installations were conversions; that is, appliances designed for coal, with gas burners inserted in them. This practice has not been generally followed by manufactured gas companies, for definite economic reasons.

The usual coal-burning appliance is designed to present a large amount of heating surface to the radiant heat emitted by the flame and fuel bed. Flue passages for the absorption of heat by convection are large because the draft loss, already large on account of the fuel bed resistance, must be kept within reasonable bounds. Heating surfaces in the flue passages of coal-burning boilers must not be so great as to cool the stack gases to a very low temperature, since a high stack temperature is required to produce sufficient draft for high rates of combustion.

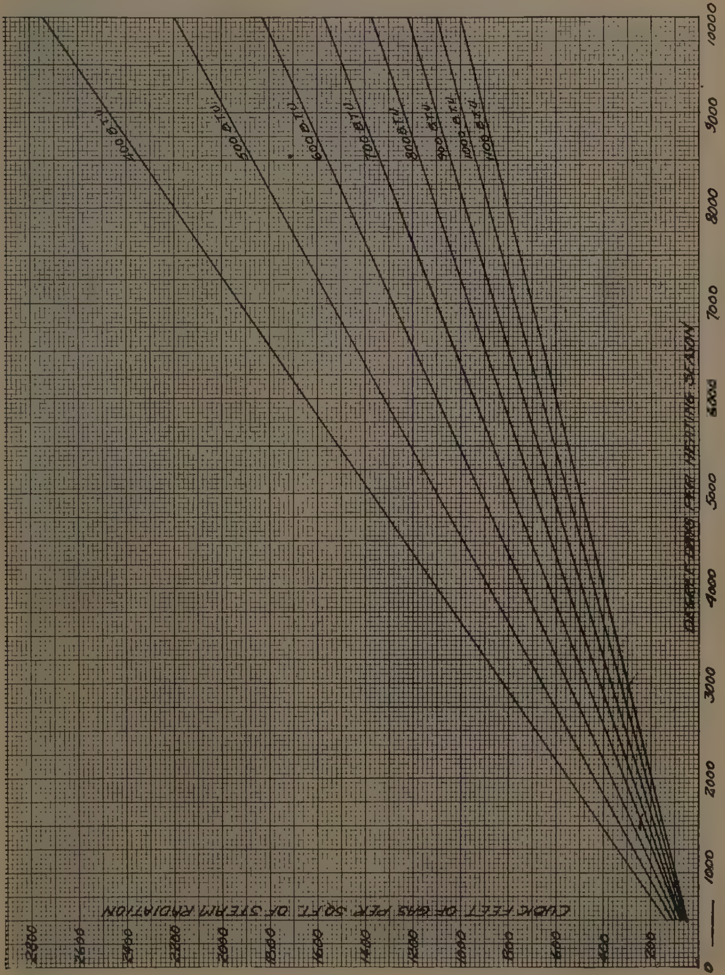


FIG. 2. GAS CONSUMPTION PER SQUARE FOOT OF STEAM RADIATION

When gas is burned in heating appliances, it may be burned either with a Bunsen (non-luminous) flame or with a luminous (radiating) flame. If a Bunsen flame is used and no attempt is made to cause this flame to produce radiant heat, such as by the use of refractories, the heating surface in the combustion chamber will absorb heat much more slowly than it would if a solid fuel were burning in the combustion chamber

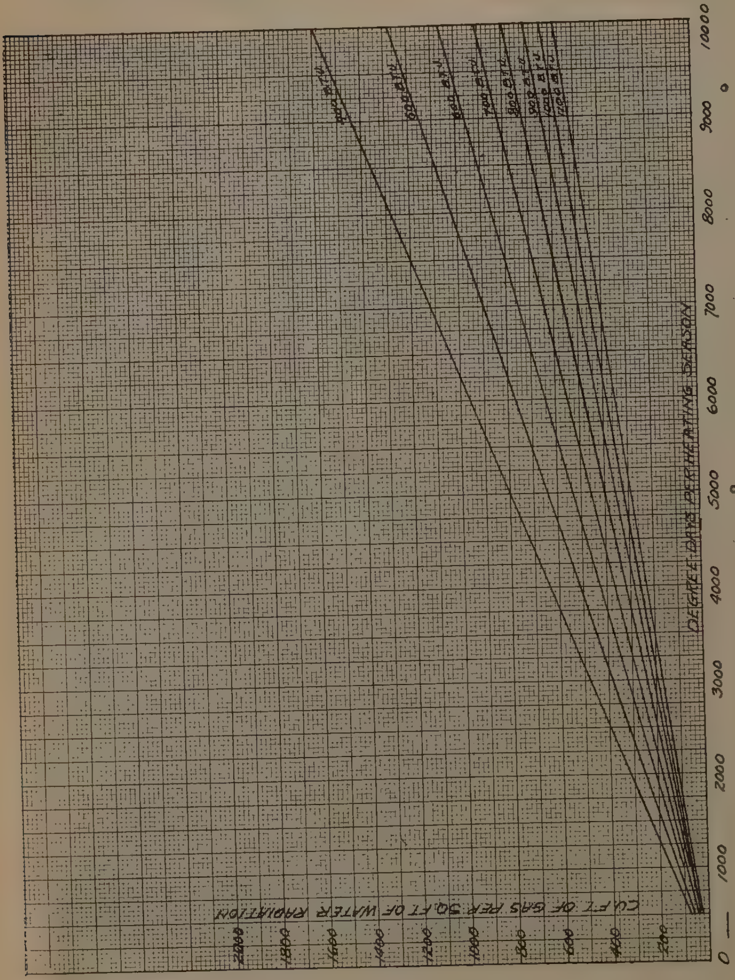


Fig. 3. Gas Consumption per Square Foot of Hot Water Radiation

with an incandescent flame and fuel bed. The heating appliance, therefore, cannot absorb enough heat to produce its rated capacity.

By burning the gas with a luminous flame, or in such a manner as to heat refractory surfaces to incandescence, the heat-absorbing surfaces in the *combustion* chamber of the appliance designed for coal can be made to do their duty. The large flue passages, however, are not as efficient as heat-absorbing surfaces. If sufficient gas is burned to cause the appliance to deliver its rated capacity, the stack temperature will be too high for efficient results. When the rate of gas consumption is adjusted to give a low-stack temperature with consequent high efficiency, the output of the coal-burning appliance will be below its rated capacity.

Gas Boilers

Gas boilers have, therefore, assumed a well-defined individuality. The usual boiler is sectional in construction with a number of independent burners placed beneath the sections. In most boilers each section has its own burner. In all cases the sections are placed very close together; much closer than would be possible when burning a soot-forming fuel. The effort of the designer is always to break the hot gas up into thin streams, so that all particles of the heat-carrying gases can come as closely as possible to the heat-absorbing surfaces. Because there is no fuel bed resistance and because the gas company supplies the motive power to draw in the air necessary for combustion (in the form of the initial gas pressure), draft losses through gas boilers are low.

Warm Air Furnaces

Gas-burning, warm air furnaces are variously constructed of cast iron, sheet metal and combinations of the two materials. If sheet metal is used, it must be of such a character that it will have the maximum resistance to the corrosive effect of the products of combustion. With some varieties of manufactured gases, this effect is quite pronounced and extremely difficult to contend with. Warm air furnaces are obtainable in sizes from those sufficient to heat the largest residence down to sizes applicable to a single room. The practice of installing a number of separate furnaces to handle individual rooms is peculiar to mild climates, such as that of southern California. Small furnaces, frequently controlled by electrical valves actuated by push-buttons in the room above, are often installed to heat rooms where heat may be desired for an hour or so each day. The same fundamental principle of design that is followed in the construction of boilers; that is, breaking the hot gas up into fine streams, so that all particles are brought as close as possible to the heating surface, is equally applicable to the design of warm air furnaces. The desirablity of using an appliance designed for gas, when gas is to be the fuel, applies even more strongly to furnaces than to boilers.

Codes for the proportion of warm-air heating plants, such as that formulated by the *National Warm Air Heating Association* (see Chapter 5), are equally applicable to gas furnaces and coal furnaces. Recirculation should always be practiced with gas-fired warm-air furnaces. It not only aids in heating, but is essential to economy. Where fans are used in connection with warm-air furnaces for residence heating, it is well to have the control of the fan and of the gas so coordinated that there will be sufficient delay between the turning on of the gas and the starting of the fan, to prevent blasts of cold air being blown into the heated rooms. An additional thermostat in the air duct easily may be arranged to accomplish this.

Space Heaters

In residence heating work, the space heater is most commonly used in the form of a radiant heater. Radiant heaters make admirable auxiliary heating appliances to be used during the occasional cool days at the beginning and end of the heating season; when heat is wanted in some particular room for an hour or two. The radiant heater gives off its heat in the form of radiant energy emitted by an incandescent refractory that is heated by a Bunsen flame. Radiant heaters, and all other types of space heaters, are preferably flue connected and should never be operated in unvented rooms, particularly bedrooms.

Luminous flame reflector heaters diffuse a large part of their heat by virtue of the radiating power of the bright yellow flame. They are usually backed by a polished copper sheet which reflects radiant heat into the room.

Convection type heaters are typified by the gas-fired steam radiator, the gas-fired tubular heater (built in radiator form) and the floor furnace. The radiator types of gas-fired heaters provide an economical form of heating apparatus for intermittently heated spaces, such as stores, small churches, and some types of offices and apartments. Since they give off the greater portion of their heat by convection they do not produce a *hot spot* within the room and are therefore capable of being operated under thermostatic control. The floor furnace is a convection type heater that is hung underneath the floor. It is generally installed with a duplex register having a warm-air outlet and a cold-air return, so that complete recirculation is secured.

SELECTION OF GAS BOILERS

While gas-burning equipment can be and usually is so installed as to be completely automatic, maintaining the temperature of rooms at a predetermined and set figure, there are in use installations which are manually controlled. Under such control the temperature variations are considerable because the human body does not react as readily to temperature changes as does a thermostat, and a greater boiler output is required quickly to regain comfortable temperatures. Experience has shown that in order to effectively overcome the starting load and losses in piping, a manually-controlled gas boiler should have an output as much as 100 per cent greater than the equivalent standard cast iron column radiation which it is expected to serve.

Boilers under thermostatic control, however, are not subject to such severe pick-up or starting loads. Consequently, it is possible to use much lower selection or safety factors. A gas-fired boiler under thermostatic control is so sensitive to variations in room temperatures, pressure of steam, or temperature of water, that in most cases a factor of 25 per cent is eminently sufficient for pick-up load.

The factor to be allowed for loss of heat from piping, however, must vary somewhat, the proportionate amount of piping installed being considerably greater for small installations than for large ones. Consequently, a selection factor for thermostatically controlled boilers must be variable. Table 5 gives selection factors to be added to the installed steam radiation under thermostatic control. They have been established by experience and are recommended by the *American Gas Association.*

Appliances should have the *American Gas Association's* approval seal and the installation should be made in accordance with their recommendations.

RATINGS FOR GAS HEATING APPLIANCES

Since a gas appliance has a heat-generating capacity that can be predicted accurately to within 1 or 2 per cent, and since this capacity is not affected by such things as condition of fuel bed and soot accumulation, makers of these appliances have an opportunity to rate their product in exact terms. Consequently all makers give their product an hourly B.t.u. rating. This is the amount of heat that is available at the outlet of a boiler in the form of steam or hot water, or at the bonnet of the furnace in the form of warm air. In the case of boilers, this rating can be put into terms of square feet of equivalent direct radiation by dividing it by 240 for steam, and 150[1] for water. This gives what is called the *American Gas Association* rating, and is the manner in which all appliances approved by the *American Gas Association* Laboratory are rated. To use these ratings it is only necessary to increase the calculated heat loss or the equivalent direct radiation load by an appropriate amount for starting and piping, and to select the boiler or furnace with the proper rating.

TABLE 5. SELECTION FACTORS FOR GAS BOILERS

EQUIVALENT CAST IRON STEAM RADIATION (SQUARE FEET OF 240 B.T.U. EACH)	SELECTION FACTOR (PER CENT)
500	56.0
800	54.0
1,200	51.0
1,600	48.0
2,000	45.0
3,000	42.5
4,000 and over	40.0

It might be stated at this point that the rating given by the *American Gas Association* Laboratory is not only a safe rating when considered from the standpoint of capacity, but is also a safe rating when considered from the standpoint of physical safety to the owner or caretaker. The rating that is placed upon an appliance is limited by the amount of gas that can be burned without the production of an amount of carbon monoxide that would be dangerous to human life. This same limitation applies to all classes of gas-consuming heating appliances that are tested and approved by the Laboratory. Gas boilers are available with ratings up to 10,000 sq. ft. of steam, while furnaces with ratings up to about 500,000 B.t.u. per hour are available.

---

[1] A value of 160 for the heat-emission of hot-water radiators is used by many engineers.

CONTROL FEATURES

One feature of the piping installation that adds to the satisfactory service rendered by gas boilers is provision for adequate and rapid venting of the air from steam heating systems. If air leaks into the steam distribution system during the period that the gas is turned off, and then vents out slowly when the thermostat calls for heat, the result will be a further cooling of the premises between the time that the thermostat calls for heat and the time that steam reaches the radiators. A freely venting steam or vapor system gives maximum economy and minimum temperature variation. When gas boilers are attached to existing heating plants, it is good practice to check the effectiveness of the venting devices and if necessary, replace them with more effective ones that will prevent the return of air into the heating system, and also to check the tightness of the piping.

On account of the ease and effectiveness with which the fuel can be controlled, gas-burning appliances are particularly adaptable to full automatic control. Standard equipment on steam boilers generally includes provision for control through a thermostat, steam-pressure regulation, and safety devices by means of which the gas is cut off either by lowering of the water in the boiler below a safe level, or by extinguishing the pilot flame. Water boilers are adapted to operation under thermostatic room temperature control and are also provided with water temperature control, as well as the safety pilot feature. Warm air furnaces can be under the control of thermostats in the spaces being heated, as well as thermostats located in the heat ducts for the purpose of preventing unpleasantly hot air reaching the heated spaces. Variations in the pressure under which the gas is supplied to the appliance are controlled by means of a gas-pressure regulator. This is a standard part of practically all makes of gas-burning heating appliances.

CROSS-CONNECTING COAL AND GAS BOILERS

Frequently, when a customer already has a coal boiler in his home, it is expedient to leave the coal boiler in place, and to cross-connect the gas boiler with it. Where gas heating is new to the community, it produces a more secure feeling in the customer's mind when putting in gas-fired house-heating equipment, if he knows that he can burn coal at any time he may desire.

For steam or vapor installations, it is desirable to have the water line in both boilers at the same level so that if desired the gas boiler may automatically take up the load if the fire in the coal boiler goes out.

CHIMNEYS

See Chapter 14 and the material relating to gas appliance chimneys contained therein.

CHAPTER 12

HEATING BY OIL

Fuel Oils; Types and Characteristics of Burners; Automatic Control; Installation Data; Costs to Operate; Domestic Heating; Industrial Heating.

THIS chapter is intended to provide the essential data on the use of oil as a fuel for heating and industrial services.

The advantages claimed for liquid fuel are:

1. Minimum space for storage.
2. Simplicity in location of storage adjacent to burners.
3. Reduction in labor and handling of fuel.
4. Elimination of ash removal.
5. Ease of control of furnace temperatures.
6. Elimination of expense of banked fires.

Each case, however, where the liquid fuel is contemplated, must of necessity, stand on its own merit. The operating cost both with oil and other fuels must be figured and the user will have to evaluate the extra convenience, after which a decision can be made as to what type of fuel should be used.

In the selection of burner equipment and in the determination of storage facilities, it is well to decide what grade of oil is to be used, its Baumé gravity, viscosity, flash point, and cold test, or temperature at which it will cease to be fluid.

The Commercial Standard Specifications of the U. S. Bureau of Standards classify fuel oils according to Table 1.

Oils, Nos. 1, 2 and 3, are used primarily for domestic purposes and do not require pre-heating. The other grades, with the exception of No. 4, are viscous at normal temperatures and require pre-heating for satisfactory operation. For commercial oil burning, oil No. 6 is used when available because of its higher heat content and lower price. Installations for the heavy oil and the labor to operate cost more than those for furnace oils but the lower price and higher heat contents frequently justify their use.

Fig. 1 gives the heat contents of various quality oils, per pound and per gallon.

FUEL OIL HEATING COSTS

The cost of producing heat by the combustion of oil depends upon the calorific value of the oil, the weight per gallon, the cost per gallon and the efficiency with which it is utilized. The efficiency of an oil burner system

TABLE 1. COMMERCIAL STANDARD FUEL OIL SPECIFICATIONS

A. Detailed Requirements for Domestic Fuel Oils

GRADE OF OIL	APPROX. B.T.U. PER GAL.	FLASH POINT,		WATER AND SEDIMENT, MAXIMUM	[a] POUR POINT, MAXIMUM	DISTILLATION TEST		VISCOSITY MAXIMUM
		MIN.	MAX.					
No. 1 Light Domestic Fuel Oil A light distillate oil for use in burners requiring a high grade fuel.	139,000	110°F	165°F or legal	0.05%	15°F	10% point, maximum 420°F	End point, maximum 600°F	
No. 2 Medium Domestic Fuel Oil A medium distillate oil for use in burners requiring a high grade fuel.	141,000	125°F	190°F or legal	0.05%	15°F	10% point, maximum 440°F	90% point, maximum 620°F	
No. 3 Heavy Domestic Fuel Oil A distillate fuel oil for use in burners where a low viscosity oil is required.	143,400	150°F	200°F or legal	0.1%	15°F	10% point, maximum 460°F	90% point, maximum 675°F	Saybolt Universal at 100°F 55 seconds

[a] Lower or higher pour points may be specified whenever required by conditions of storage and use. However, these specifications shall not require a pour point less than 0 deg. fahr. under any conditions.

B. Detailed Requirements for Industrial Fuel Oils

GRADE OF OIL	APPROX. B.T.U. PER GAL.	FLASH POINT,		WATER AND SEDIMENT, MAXIMUM	POUR POINT, MAXIMUM	VISCOSITY, MAXIMUM
		MIN.	MAX.			
No. 4. Light Industrial Fuel Oil An oil known to the trade as a light fuel oil for use in burners where a low viscosity industrial fuel oil is required.	144,500	150°F.	See Note [b]	1.0%	See Note [c]	Saybolt Universal at 100°F 125 seconds
No. 5 Medium Industrial Fuel Oil Same as Federal Specifications Board Specification for Bunker Oil "B" for burners adapted to the use of industrial fuel oil of medium viscosity.	146,000	150°F		1.0%		Saybolt Furol at 122°F 100 seconds
No. 6 Heavy Industrial Fuel Oil Same as Federal Specifications Board Specification for Bunker Oil "C" for burners adapted to oil of high viscosity.	150,000	150°F		Water sediment 1.75% 0.25%		Saybolt Furol at 122°F 300 seconds

[b] Whenever required, as for example in burners with automatic ignition, a maximum flash point may be specified. However, these specifications shall not require a flash point less than 250 deg. fahr. under any conditions.

[c] Pour point may be specified whenever required by conditions of storage and use. However, these specifications shall not require a pour point less than 15 deg. fahr. under any conditions.

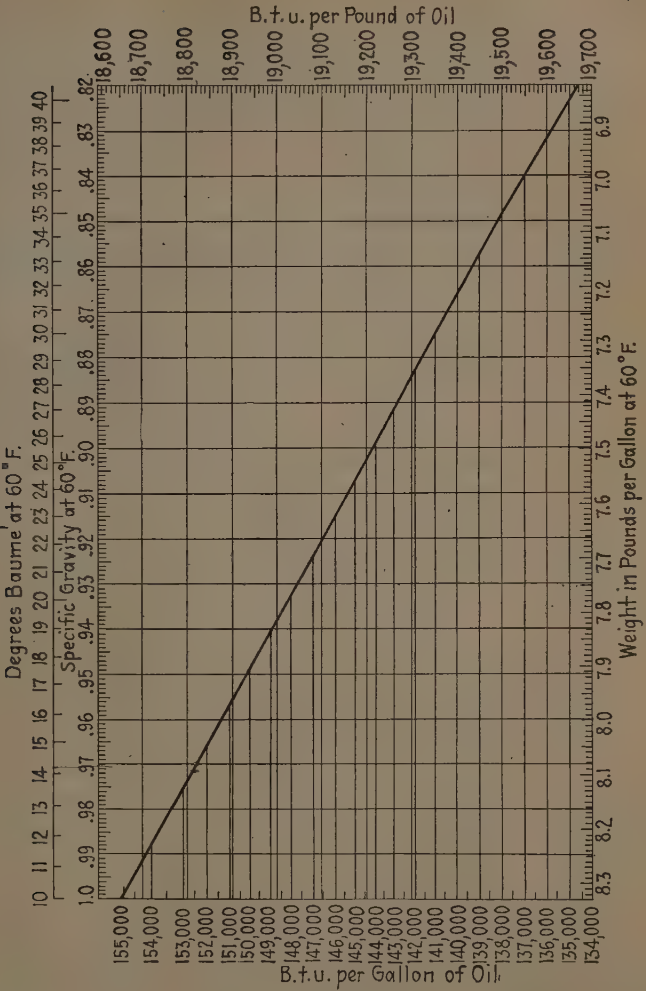


Fig. 1. Heat Content of Various Quality Oils

will depend entirely upon the individual installation, but it is reasonable to assume an increase in efficiency of 10 to 15 per cent over coal.

The chart (Fig. 2) can be used for estimating the cost per 1,000,000 B.t.u. for various heat contents per gallon (see Fig. 1), and costs per gallon and is based on an overall efficiency of 60 per cent. The cost in dollars per 1,000,000 B.t.u. for other efficiencies can be estimated from the following formula:

$$Z = \frac{1,000,000 \times P}{C_o \times W \times E_o}$$

where

Z = cost of oil in dollars per 1,000,000 B.t.u.
P = cost of oil in cents per gallon.
C_o = calorific value of oil, B.t.u. per pound.
W = weight of oil per gallon, pounds.
E_o = efficiency of heating system.

For example, if the cost of oil is 7¼ cents per gallon, the heat content 141,000 B.t.u per gallon (the product of C_o and W) and the efficiency 65 per cent, the cost per 1,000,000 B.t.u. will be:

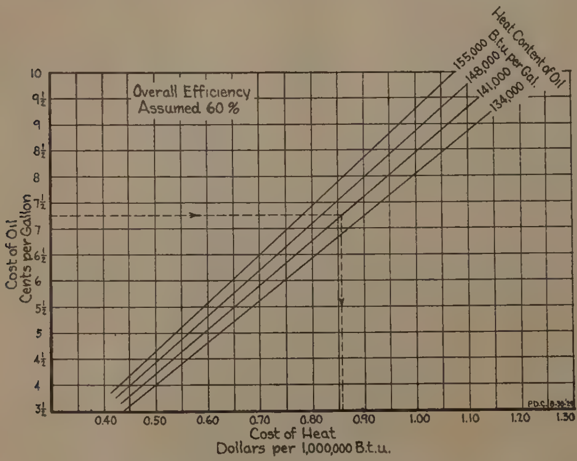


FIG. 2. COST OF HEAT PER 1,000,000 B.T.U. WITH OIL FOR VARIOUS HEAT CONTENTS PER GALLON

$$Z = \frac{1,000,000 \times 7.25}{141,000 \times 65} = \$0.792 \text{ per } 1,000,000 \text{ B.t.u.}$$

It is frequently desirable to compare the cost of producing heat with oil with the cost for other fuels, giving consideration to the efficiency of the heating system as well as the calorific value of the fuel and the cost. Information concerning heating costs with other fuels is given in the chapters on Heating by Coal, Heating by Gas and Heating by Electricity.

MECHANICAL AND COMBUSTION SOUNDS

The perceptible sound incident to the combustion of oil is dependent largely upon the means employed to mix the oil and air and the rate of heat liberation per unit of combustion volume. It is obvious that this characteristic can be controlled to some degree by the design of the burner and by the method of application to the combustion chamber of the heater. A further controllable factor is the amount of mechanical sound which will vary with design, mechanical condition and the adjustment of the unit. The transmission of both mechanical and combustion sounds can be governed to some extent by the utilization of some means of absorbing vibration.

DOMESTIC HEATING

With the large number of domestic oil-heating units that are available, it is important to look into the construction of the burner as to design, workmanship and materials, but one of the most important points to be kept in mind is the ability of the man making the installation and adjusting the burner to meet the needs of each application and to give the proper service to the installation. Further considerations in making a choice are the adaptability of the particular burner to the boiler, its ability satisfactorily to burn the fuel that is available in a given locality, and its quietness of operation.

Fuel Oils for Domestic Heating

Oils Nos. 1 to 3 are those used for domestic heating installations as they are available in most territories and they do no require pre-heating. They are suitable for installations requiring up to 30 gal. per hour, or more, in districts where heavy oil is not available. Burners should be selected that will satisfactorily handle the grade of oil available and owners should be advised to employ only the grade of fuel for which the burner is designed, except that a lighter grade than the one specified, can be used in most any type of burner.

Methods of Operation

There are three fundamental methods of operation: (1) Intermittent; (2) High-Low Continuous Flame; (3) Graduated Continuous Flame. The majority of burners operate on the intermittent system.

Intermittent Operation: With this method of operation the flame is all on or all off. Usually when the flame is on it is adjusted for fuel and air to carry from 20 to 25 per cent in excess of the maximum demand for heat. Thus, during a protracted cold spell, this type of burner operates nearly continuously and must be capable of maintaining continuous operation for many hours. On warm days, when no heat is needed, the burner is, of course, inoperative. Throughout the average heating season such as is experienced in the latitudes of Chicago and New York, the burner operates from one-quarter to one-third of the time.

High-Low Continuous Flame: As the name would indicate, this type of burner operates on a low flame when there is little or no demand for heat and a high flame when heat is required. The low flame serves as a pilot light and must be sufficiently small to avoid waste of fuel and discomfort during unseasonable warm days in the spring and fall. As with the intermittent type of burner, the high flame should deliver from 20 to 25 per cent in excess of the maximum demand for heat.

Oil and air supply controls are usually interlocking and must be adjusted for both operating positions. If mechanical draft is used, the burner motor and other moving parts must be properly designed to operate continuously throughout the heating season.

Graduated Continuous Flame: In this type of burner, the operation is continuous as with the high-low type with high and low limits of combustion rate to satisfy the greatest and least demands for heat. However, the burner is arranged to operate at several intermediate steps instead of at only two points, so that the rate of combustion is proportioned more nearly to the demand for heat. With manual operation, the oil and air may be separately adjusted to any required rate of combustion, but for automatic operation, the oil and air controls must be interlocking and must be capable of permanent separate adjustment at the several intermediate steps. With mechanical draft, the burner motor and other moving parts must be designed for continuous service.

Relative Merits: Engineers are not in agreement concerning the relative merits of the three methods of operation from the standpoint of fuel consumption. The high-low or graduated systems may have a slight advantage during the coldest weather, whereas, the intermittent burner will usually be more economical during the milder weather. Over the entire heating season, the total amount of fuel used usually will be very nearly the same.

Types of Burners

There are two distinct types of oil burners used for oil heating—the natural draft burner and the mechanical draft burner. Their names indicate the manner in which the air for combustion is obtained.

Natural Draft Burners: The natural draft burner requires no motor and usually has no moving parts. The air for combustion is supplied by the pull of the chimney and is, therefore, dependent upon the construction of the latter. This type of burner is often incorrectly referred to as a *gravity* type burner. Gravity indicates the manner in which the fuel is fed to the burner and a gravity system is applicable to either natural draft or mechanical draft burners. This type of burner is more susceptible to changes in the weather, wind currents about the chimney and other factors which cause a variation in the draft intensity than is the mechanical draft burner, unless the effects of this variation in draft can be overcome in the design of the chimney, in the design of the burner, or by the use of a draft regulator. A natural draft burner usually is limited to small heating loads, depending in size somewhat on the design of burner, and for best operation requires the use of lighter oils. It has in its favor a low first cost, simplicity of design, and requires no power for operation.

Mechanical Draft Burners: The mechanical draft burner is motor-driven and often the air for combustion is supplied by a fan or blower. Generally, where a fan is used it is of sufficient capacity to supply the entire amount of air for combustion when the burner is operating at its maximum capacity. Often where a blower, either of a centrifugal or positive pressure-type is used, only a portion of the air required is supplied under pressure, the balance being induced by the injector action of the air from the blower, plus the natural draft from the chimney. The air from the blower usually is used to aid in the atomization of the fuel. The blower produces a comparatively constant supply of air under varying draft conditions, and therefore, maintains a uniformly efficient combustion condition.

Another classification of burners used has to do with the means employed to prepare the fuel for combustion. The terms are vaporizing and atomizing burners.

Vaporizing Burners: In the vaporizing burner the fuel is prepared for combustion by the addition of heat. The heat serves to convert the liquid fuel into a vapor which is mixed with the air for combustion either just before or during the combustion process. Blue flame combustion is sometimes advocated, but as a blue flame radiates very little heat it is of no particular advantage in a boiler or furnace that has been designed for coal burning, wherein the major heat transfer is secured through radiation. By vaporizing the fuel, moving parts can be eliminated and the fire is easy to control at low combustion rates. However, vaporizing burners require a light fuel for best results and with poor design there is the possibility of carbon trouble due to cracking or decomposition of the oil in the vaporizing chamber.

Atomizing Burners: In the atomizing burner the fuel is broken into a fine mist which is mixed with the air for combustion either just before or progressively during the combustion process. The particles are so fine that they are quickly vaporized by the heat of combustion and if properly mixed with sufficient air will burn with a clean hot flame. There are many ways to atomize oil—under pressure through a small orifice, by compressed air or steam, by centrifugal force from the edge of a rapidly rotating cup or disc and by numerous other equally effective methods. Any of the methods used will break the oil into very fine particles and when applied with intelligence will give satisfactory results. With the atomizing type of burner cheaper oils may be utilized than with other types of burners; they will start readily from a cold condition and can be applied to installations requiring a high fuel consumption.

Systems of Ignition

The methods of ignition may be classified as follows:

1. Manual.
2. Continuous gas pilot.
3. Expanding gas pilot.
4. Continuous electric spark.
5. Intermittent spark.
6. Combination electric spark and gas.

Ignition of the high-low and graduated continuous flame burners is *manual*, by means of a gas or oil torch. No automatic ignition devices are required. If the oil is prepared for combustion by vaporization, sufficient time is required to preheat the vaporizing plate or chamber. If the oil is atomized, preheating is unnecessary.

In most natural draft burners the oil is lighted manually with a torch through the fire door, although some of them are provided with gas, electric or oil pilot, at the option of the owner.

The *continuous gas pilot* method of ignition is simple, but to insure an adequate flame in case the pressure drops, an excessively large flame must be used, consuming an excessive amount of gas.

With the *expanding gas pilot* system, the pilot is small during the off period of the burner and is automatically increased when the burner is started. After allowing a sufficient time for ignition, it is then automatically decreased again. The valve controlling the size of the pilot flame is actuated by means of a solenoid or a small motor.

Continuous Electric Spark Ignition: By means of a transformer the line voltage is stepped up to many thousand volts, causing a spark to jump between two electrodes placed so as to ignite the atomized oil. This spark continues as long as the burner is in operation.

With the *intermittent spark* system, the spark continues only long enough to ignite the oil. In some burners, the electrodes are then automatically removed from the zone of the atomized oil.

With the *combination electric spark and gas* system, the electric spark ignites the gas pilot, which in turn ignites the oil.

Temperature Control

There are two methods of maintaining the desired temperature—by thermostat and by boiler control.

When thermostatic control is used, a room thermostat is used to indicate the temperature of the room and to control the operation of the burner so as to maintain the desired temperature between limits of plus or minus 2 deg. This instrument is mechanically accurate and will function according to the temperature conditions of its location. Therefore, it should be located with care. Most people prefer to have it located in the living room. It should be on an inside wall about 5 ft. from the floor at the breathing level, protected from abnormal drafts such as come from stairways, or entrances; it should not be placed near chimney, radiators, registers, hot water or steam pipes or other sources of heat. Special care should be taken to avoid concealed steam or hot water pipes. Another important factor in maintaining a satisfactory uniform temperature throughout the house, and one which cannot be controlled by the thermostat is the matter of distribution of the heat within the various rooms. It is important that the distribution be proportioned so that when the desired temperature is reached in the room where the thermostat is located the same temperature will have been reached in all of the rooms of the house.

When the *boiler control* system is used, the pressure in the boiler operates against the diaphragm or bourdon tube and opens or closes the burner circuit by means of a platinum point or mercury tube switch. Diaphragms or tubes of varying sensitivity may be selected to accommodate wider ranges of pressure, and the starting and stopping limits may be adjusted to meet different weather conditions. Of necessity, this type of control is only semi-automatic, but in large buildings, where it is impossible to locate a thermostat which would control properly the temperatures of many rooms, occupied by many different tenants, this method of control must be used if automatic operation is desired.

Due to the fact that hot water and warm air heat are used mostly in smaller residences, thermostatic control is effective and control of temperature at the hot water boiler furnace casing is seldom employed. (For a further discussion of this subject, see Chapter 17, Automatic Heat Control).

Safety Controls

Apparatus is usually provided to control the operation of the burner to prevent overheating of the boiler or furnace. In the case of a steam boiler, such a device prevents the development of abnormal pressures; in the case of a hot water boiler, it prevents too high a water temperature; and in the case of a warm air furnace, it prevents too high a temperature in the warm air chamber.

A safety control is also provided to establish a time limit within which the oil must be ignited every time the burner is started, and to shut the burner down if for any reason the ignition does not take place or if there is a cessation of combustion. The most important safety devices used for this purpose are as follows:

1. *Stack Safety:* This device consists of a spiral bi-metallic coil, similar to the warm-air limit control actuating one or two mercury tube switches depending on the type of circuit used, and serves to maintain the control motor or relay device in the burner on position providing the heat of the products of combustion causes it to reach a certain temperature within a certain specified length of time, 20 seconds or so.

Should the oil fail to ignite, the stack will remain cold, and at the expiration of the allotted time, the burner will be shut off. The accumulation of soot on the bi-metallic spiral affects the operation of this type of switch, and for this reason, some burners force air through a tube passed through the combustion chamber, the stack safety being actuated by the air blown through this tube.

2. *Radiant Heat Safety:* In this device the radiant heat of the flame takes the place of the heat of the products of combustion to actuate the shut-off device. In one type a black surface absorbs the radiant heat causing it to expand and so shut down the burner. In another type, two bulbs are filled with a gas and connected by a tube at the bottom. One bulb is clear and one is black. The radiant heat of the flame causes the gas to expand in the black bulb forcing a quantity of mercury in the connection tube up into the clear bulb making the necessary electric contacts.

With intermittent operation, all the methods of temperature control using thermostats, boiler controls, electric safety devices, expanding gas pilots, etc., are used. Where certain steps must be followed each time there is a call for heat, an accurate timing device is necessary to insure the proper sequence of steps and the correct time intervals. This timing device consists either of a small induction motor which actuates the various gas and oil valves and electric switches, or of a system of relays and electric contacts opened and closed by magnets or electrically heated by-metallic strips.

3. In the absence of an electric safety device, some burners use a *shut off* in the form of a valve which stops the supply of oil to the burner, or a switch which breaks the burner motor circuit. In the event of a flame failure, a small quantity of oil runs into a bucket which overcomes a counter weight and closes the oil valve or opens the switch. Sometimes the counter weight is pivoted so as to pass dead center and lend its weight to the weight of oil in the bucket serving also to deliver an impact to firmly seat the valve or open the switch.

4. In some burners a special *thermostatic element* serves to shut off the gas in the event that the gas pilot goes out.

Low Water Safety: Due to rapid evaporation on starting, particularly with steel and copper tube boilers of small water content, a low-water safety is essential. This device consists of a float chamber mounted at the water line between the boiler and the glass gage. A lowering of the water line causes the float to depress one end of a mercury tube switch stopping the burner. Even with slow heating boilers of large water content and weight of metal, the low-water safety is necessary, as an oil-fired boiler is not subjected to the same observation and care as a boiler fired two or three times a day with coal.

Burner Installations

Most oil burners are installed in heaters which are designed for coal, and the results are usually quite satisfactory. Where a heater is being purchased for use with oil heating equipment care should be taken to select one that has long flue passes, that do not short-circuit the gases from the combustion chamber to the flue. There are several boilers which have been designed especially for oil burning and which are very efficient and economical. Every oil fuel boiler should be provided with an automatic feed water regulator or a low-water cut-off as the boiler is often neglected; since the automatic features eliminate the necessity of a daily inspection.

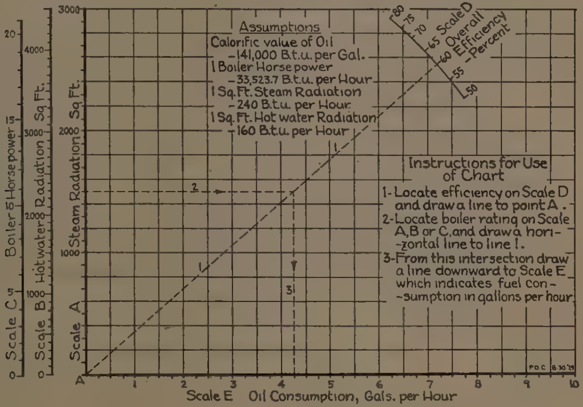
With many of the cast iron water-tube sectional boilers it has been found possible to increase the rating by using oil as a fuel. This increase amounts to from 10 to 25 per cent, but boiler equipment should not be selected on this basis without the knowledge and approval of the boiler manufacturer. This increase in rating usually is not possible with round boilers. Where round boilers are used with oil heating equipment it is best to select a boiler that has extra indirect heating surface in the form of intermediate sections.

In applying oil heating equipment to existing coal burning boilers it is often advisable to baffle the passes in order to lengthen the travel of the hot flue gases and also to keep them in closer contact with the heating surface. In fire-tube boilers it is often desirable to use retarders inserted in the tubes so as to give the flue gases a spiral motion and keep them in contact with the surface of the tube.

Warm air furnaces are used satisfactorily with oil burners. It is, of course, important that they shall have very tight joints, and these should be maintained carefully, with an inspection and cementing at least every year. A good chimney draft especially is important with warm air furnaces, as it will tend to insure that inleakage of air shall be more common than outleakage of products of combustion through the furnace cracks.

Installations should always be made by trained men under the direction of the burner manufacturer as every burner has peculiarities that should be given consideration when the installation is made. It is also important that the burner should be correctly adjusted for each installation as loss in efficiency more often results from poor adjustment rather than from poor design. A burner should have sufficient capacity to develop full rating of the heater which it serves and it is preferable that it have some excess; it should also be adjustable over a range from 50 to 100 per cent rating (See Fig. 3). The flame adjustment is best determined by a flue gas analysis, but a good check can be made by noting the color of the flame. A white flame indicates excess air or insufficient oil; a red, smoky flame insufficient air or excess oil, and an orange flame just tipped with red indicates efficient and clean combustion. The boiler room should be well ventilated so that the burner can obtain an adequate supply of air at all times.

Burner and tank installation and all electrical work should be installed in accordance with local ordinances. If no local rules are in force the rules recommended by the *National Board of Fire Underwriters* should be followed.



Assumptions
Calorific value of Oil
–141,000 B.t.u. per Gal.
1 Boiler Horse power
–33,523.7 B.t.u. per Hour
1 Sq. Ft. Steam Radiation
–240 B.t.u. per Hour
1 Sq. Ft. Hot water Radiation
–160 B.t.u. per Hour

Instructions for Use of Chart
1- Locate efficiency on Scale D and draw a line to point A.
2- Locate boiler rating on Scale A, B or C, and draw a horizontal line to line 1.
3- From this intersection draw a line downward to Scale E which indicates fuel consumption in gallons per hour.

Fig. 3. Full Load Rate of Oil Consumption for Heating Boilers

Domestic Hot Water Heating

For domestic hot water supply a steam coil heater is quite satisfactory when steam or vapor is used, and with suitable controls on the hot-water tank, can be used the year round at a very reasonable cost. An iron shell type of heater with local hot water circulating lines between the shell and the water of the boiler and with a copper coil in the shell, through which the water in passing is heated, is very satisfactory with either steam or hot-water boilers, but care must be taken to have such heaters of ample capacity and connected to ample-sized storage tanks, especially with hot water boilers. This system may also be very successfully used the year around if an automatic control such as described above under Temperature Control is used. Small size oil burners are made which are suitable for installing under small hot-water heaters and which may be controlled automatically by a thermostat in the hot-water tank. A coil in the combustion chamber is not generally satisfactory for service hot-water heating.

Oil Storage Tanks

Tank installations should always be made in accordance with local regulations, or in absence of these, the regulations of the *National Board of Fire Underwriters* should be followed. These latter regulations permit the oil to be fed by gravity from an exposed 275 gal. inside storage tank, if desired, and if proper precautions are taken to prevent an abnormal flow of oil. Inside tanks should be installed on non-combustible supports and located at least 10 ft. from the burner. In some localities it is permissible to install two 275 gal. tanks with a three-way valve in the feed line connecting the two tanks, permitting gravity feed from either tank. This type of installation has many advantages and is rapidly coming into favor with local authorities having jurisdiction over the installation of oil heating equipment.

For large installations a very desirable installation is with an outside buried tank of at least 1,100 gal. capacity. Where it is impractical to locate this tank below the level of the burner, it is necessary to use some means to prevent the siphoning of oil from the tank, in case of a break in the fuel supply line. There are several devices for this purpose which have been approved by the Underwriters' Laboratories. The use of a large buried tank eliminates the necessity of constantly watching the fuel supply, and in some cases will permit the purchase of fuel at enough lower price to pay for the difference in installation cost. All tanks should be provided with direct reading gages to give a constant check on the amount of fuel on hand. All tanks must be vented and should be located so that the filling line terminal is near the drive, or curb, to facilitate delivery from the tank truck.

Chimney Design

Although slightly less draft is required for oil burning equipment than is required for coal burning equipment, and a smaller chimney area ordinarily would be satisfactory, it is recommended that the chimney be designed to meet the boiler manufacturer's requirements as specified for coal burning. It is preferable to have the oil burner flue isolated from other flues as this may be helpful in preventing any mechanical sound from being transmitted to the rooms of the house. A well designed chimney that will insure uniform draft conditions is just as important to an oil burner as it is to a coal-fired heating plant. For further information on this subject, see Chapter 14, Chimneys.

INDUSTRIAL HEATING

Burners

Atomizing burners are used exclusively for installations with heavy oil. Of these, there are three types: steam atomizing burners, air atomizing burners, and mechanical atomizing burners.

The *steam atomizing* burner has two classifications, the outside mixing and the inside mixing type. With the outside mixing type, the oil is forced through an orifice at a comparatively low pressure and just as it emerges from this orifice it is struck by a jet of steam traveling at a high velocity from a direction at right angles with the flow of oil. The steam jet breaks the oil and injects it into the combustion chamber in a fine spray or mist. The inside mixing type has a turbulence mixing chamber between the steam orifice and the burner opening. The mixing inside the burner permits some vaporization of the lighter hydrocarbons due to the heat in the steam, so that the mixture issuing from the burner-opening lights readily and maintains a steady burning flame. Steam burners require from 1.5 to 5 per cent of the total steam generated for atomization; 2 to 2.5 per cent being a good average. This average easily can be maintained by correct adjustment of the burners. For the best results the steam should be dry.

Air atomizing burners using high-pressure air are similar in design to those using steam. This type is not used as much as low-pressure air burners. Low-pressure air burners use comparatively large volumes of air under pressure of 1½ to 2½ lb. per square inch. If the blowers or compressors supplying the air are steam driven, they will require approximately 2½ to 3 per cent of the steam generated for the motive power, but the exhaust steam is available for use in the pre-heaters, so that the steam consumption for air atomizing burners compares very favorably with that for steam atomizing burners. The first cost, however, is greater with air atomization than with steam atomization.

Mechanical atomizing burners are those which atomize the oil without the aid of air or steam, although it is common practice to use air under low pressure in connection with mechanical atomizers further to atomize the fuel, though this is not essential. The high-pressure atomizer forces the oil through a small orifice under high pressures (100 to 200 lb. per square inch). The oil is given a rotary motion by slots cut tangentially to the diameter of the orifice of the burner, so that the centrifugal force of the oil leaving the orifice acts as an aid in atomizing the fuel.

Another type of mechanical burner is the rotary cup burner. In some burners the cup is positively driven by an electric motor or steam turbine and has a fan mounted on the same shaft so as to provide a portion of the air for combustion under pressure to aid in the atomization of the oil as it leaves the edge of the rotating cup. Another type of rotary cup burner has the cup driven by an air turbine utilizing the velocity of low-pressure air from a centrifugal blower. This blower usually is located at a remote point from the burner and is of sufficient capacity to supply all of the burners in the battery, although there are some installations where each burner has its own individual blower. While the first cost of mechanical atomizing burners is usually comparatively high, the steam driven type has the advantage of returning all the exhaust steam for heating the boiler feed water. Further advantages of this type are simplicity and economical operation with uniform combustion regulation.

Burners for commercial installations are usually manually operated although they may have semi-automatic controls which vary the amount of air and oil as the load fluctuates.

For some burners, the air for combustion is partially supplied from a blower and is used to aid in the atomization of the fuel, the balance being induced by the natural draft through openings in the refractory hearth of the combustion chamber. These openings should be arranged to conform to the shape of the flame from the burner so that the air comes in contact with burning fuel and is not permitted to escape unused through the boiler passages and up the stack. With other burners there is an air register, designed as part of the burner, which admits the air by natural draft through adjustable vanes, giving a rotating motion to the air as it enters the combustion chamber about the atomizer. Some installations are provided with forced draft by connecting the air register to a duct from a fan blower.

There are many factors that should be taken into consideration when selecting burners for application to a particular installation. A good burner should be flexible in its adjustments; it should be adjusted easily over a considerable capacity range; it should be suitable for the lowest grade of oil that will be used, and its design should permit the shaping of the resulting flame from the burner so that the flame will fit the combustion chamber closely. A flame that does not fit properly the shape of the combustion chamber permits air to escape around the flame without mixing with the fuel and is, therefore, responsible for inefficient combustion results. If possible, it is best to use a single burner, rather than burners in multiple, wherever the shape of the flame can be adjusted to meet the combustion chamber requirements and whenever the burner has sufficient capacity and flexibility to meet the variable loads imposed on the boiler. Single burners ordinarily meet the requirements of buildings such as schools, theaters, churches and apartments. For large office and commercial buildings the boilers usually are of such size as to require two or more burners per boiler in order to obtain the required flame application and flexibility of control.

Draft for Industrial Burners

There are several reasons why less draft may be required with oil burning equipment than is necessary where coal is used as a fuel. The principal reasons are that the draft loss through the fuel bed and grate is eliminated, and as a general rule the stack temperatures are lower and the volume of gas less than with coal. For this reason the cross-sectional area of the stack may be smaller. Some authorities say that it may be safely assumed as 60 per cent of the area that would be furnished for an equivalent coal-fired boiler. In determining the height of the stack, care should be taken to secure sufficient draft for the maximum requirements of the boiler and no more. It is advisable, therefore, to follow the recommendations of the heater manufacturer, and if possible the burner manufacturer should also be consulted, so that the air-ways shall be designed correctly for the available draft, and provide for sufficient air to develop the rating of the boiler in the combustion volume available.

Furnace

Under average conditions the combustion volume should be such that a release of 40,000 B.t.u. per cubic foot per hour shall not be exceeded at 100 per cent of the boiler rating. This is not the maximum heat release possible, but it is representative of good practice.

Where oil-burning equipment is applied to existing coal-burning boilers excess draft can be corrected by using a damper. It also is advisable in many cases to use baffles to provide for a longer flue travel. In fire-tube boilers it is good practice to insert retarders in the tubes of a type which

e the flue gases a spiral motion and which will keep the gases in
t with the surface of the tube.

ary Apparatus

ardless of the type of burner used, the installation of the oil system,
includes the tank, heaters, strainers, pumps and piping, is im-
it.

ks should be installed in accordance with the local rules for the
e of oil fuel, but in the absence of local regulations, it is suggested
e rules and regulations of the *National Board of Fire Underwriters*
owed. The size of the storage tank is often governed by the amount
e available but it is a question that should be given due considera-
aking into account the time required for delivery, the daily fuel
ments, and the price in various quantities. Where purchases are
ade by carloads it is advisable to have at least a 15,000 gal. tank.

e oil consumption can be fairly accurately checked by gaging the
ith a stick gage through the measuring well, the use of an oil meter
most logical method of determining fuel costs and for gaging the
n between fuel consumption and work performed. It is recom-
d that each tank be equipped with a direct reading gage so that a
nstant check may be kept of the fuel on hand.

nall heater usually is installed in the storage tank around the
n inlet. This heater is used to reduce the viscosity of the oil so
can be pumped readily. The oil heaters are usually steam coils,
me local regulations require that this heating be done by hot water
The oil is delivered from the pump to the supply line for the
s and is passed through larger heaters where the temperature is
o a point that insures the viscosity being low enough for atomiza-
This temperature is variable for different oils but will usually be
en 150 and 200 deg. fahr. It is important that oil be kept at a
n temperature for satisfactory atomization. This is done by means
omatic temperature regulators which open and close the steam
valve to the heater coils. From the heaters the oil is delivered as
as possible to the burners for atomization.

l fuel oils contain a certain amount of foreign matter in suspension,
portant that the oil line have large strainers with sufficient screen
permit their being used for some period of time without the screens
ng clogged and preventing the flow of oil. The best practice calls
iners in duplicate on the suction side of the pump, and additional
rs, known as discharge oil strainers, on the delivery side of the
It is important that strainers be located where they are readily
ble for cleaning. For small commercial installations, the oil pumps
ally of the rotary type driven by electric motors and are sometimes
rated into the design of the burners. For large installations, steam
d piston type pumps are commonly used. It is recommended that
and heaters be installed in duplicate. This also is required by
cal regulations where the boiler service is used in connection with
the fire protection apparatus.

the various types of burners which are being used, there have
eveloped oil-handling systems which differ in their construction

and arrangement of piping, pumping and tank equipment. One of the most widely used oil systems at the present time is the continuous circulation system. In this system, the oil is pumped from the tank by the oil pump and is delivered to the burner supply line; any excess oil is bypassed through a regulating valve back to the tank or to the suction side of the oil pump. In this way the proper atomizing temperature of the oil is maintained and choking or accumulation of sediment in the supply line is avoided. In the layout of the piping for pre-heated oils it is important to keep the oil supply pipe below the level of the burner and without traps, so as to prevent the formation of vapor pockets which are liable to shut off the fuel supply or cause irregular operation.

REFERENCES

Some Hints on Installing and Operating Domestic Oil Burners, By C. H. Chalmers (JOURNAL, A. S. H. V. E., October, 1925).

Design and Performance of Domestic Oil Burners, By W. C. McTarnahan (JOURNAL, A. S. H. V. E., August, 1928).

Application of Oil Burners to Various Types of Domestic Heating Systems, By J. H. McIlvaine (JOURNAL, A. S. H. V. E., March, 1929).

Handbook of Domestic Heating, published by *American Oil Burner Association*, October, 1928.

CHAPTER 13

HEATING BY ELECTRICITY

Desirable Features; Cost Comparisons; Off-Peak Systems of Heating; Domestic Hot Water Heaters.

THE use of electricity for both domestic and industrial heating is increasing and the desirable features of this type of heating are as follows:

1. Minute and exacting regulation of temperatures.
2. Extreme simplicity and automatism of operation with minimum maintenance.
3. Freedom from the dangers attending the presence of a flame.
4. Freedom from handling and disposition of resulting products of combustion.
5. Reliability of source of supply.
6. Maximum efficiency of conversion of the fuel into usefulness.
7. Cleanliness.

These features embrace all the requirements of an ideal heating agent, except one: low cost. Where electrical energy is sufficiently low priced, it is being used for heating buildings.

Heaters of both radiant and convection types are available. The resistors of these heaters are made usually of nickel-chromium wire or ribbon. Radiant type heaters are seldom employed in house heating, except for booster-heaters or emergency heaters in small rooms which are isolated.

HEATING COSTS WITH ELECTRICITY

The major recent development in the domestic field of electrical heating has been the educational effort to demonstrate to the electric light and power companies and to the consumers, the availability of comparatively low cost electricity, if taken at certain hours, when the cost can be made low, namely, the off-peak hours during which the stations and a considerable part of the lines are not worked to full capacity.

Cost comparisons between various fuels and electricity for house heating should be made on a heat unit basis, giving due consideration in each case to efficiency. The cost of heat per 1,000,000 B.t.u. for any rate per kilowatt-hour for electricity may be determined from Fig. 1. A comparison between the cost of heating with electricity and the cost of heating with other fuels may be made by referring to similar charts in the chapters on Heating by Coal, Heating by Oil and Heating by Gas.

The importance of insulation and weatherstripping for electrically heated houses cannot be over-emphasized. The remarks on page 224, Chapter 11, on this subject, apply to even a greater degree here.

The more costly the fuel, the greater the need for insulation, weatherstripping and storm sash. Unless the heat losses of a building to be heated by electricity are reduced to a low point, the cost will be excessive as compared with other fuels.

STORAGE SYSTEM OF ELECTRICAL HEATING

Recently there has been developed a new system for applying electricity to house heating whereby it has become possible to purchase current at low cost. Advantage is taken of the high capacity of water for storing heat from electric energy purchased from the utility company.

Large tanks of water are heated at night when the energy is available at a lower cost, and this stored heat is drawn upon as required through the day. Such a system has been applied to houses provided with hot water, steam and warm air heating systems.

Power companies in various parts of the country are investigating and sponsoring development of off-peak electrical house heating and are preparing to support its widespread use. The nature of the load and its bettering effect on the power factor curve is favorable both to the public utility and the consumer.

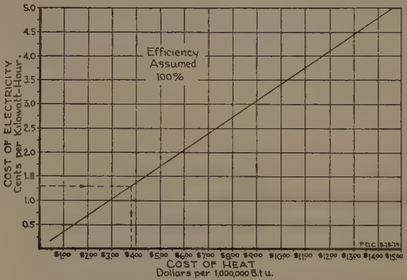


Fig. 1. Chart for Estimating Cost per 1,000,000 B.t.u. for Electricity

The characteristics of the electric heating load, when used with the thermal storage system are ideal from the electrical operating standpoint. The units are non-inductively wound so that the load is unity power factor, and the load is timed so as to be used exactly at the time specified by those responsible for the operation of the systems. It is, therefore, corrective in its effect and tends to fill up the valleys in the load curve. It corrects the inherent peak characteristics of the domestic load in that it places a load at hours when otherwise a resident would use no electricity. The electricity is taken at the hours when the electric light and power company most desires load and the result of the energy—the stored heat—is used during the day when it is needed to heat the house.

Cost of Electricity

The public service companies assign the periods during which electricity may be used for such heating, and charge usually a base rate of about 1 cent per kilowatt-hour. Even this rate does not make electricity a price-competitor of oil and gas for heating, but is low enough to attract consumers.

Hot Water System

The tank used with these storage systems is heavily insulated and is equipped with built-in electrical heating elements. The size of the tank is a function of the heat loss of the building and of the length of the periods allowed by the utility company, during which electricity may be used for heating. The water in the tank is warmed to a temperature of about 300 deg. fahr. It is then circulated, usually by an electric pump through the heating system in the building, the regulation of the flow of the water in the system being thermostatically controlled.

Warm-Air System

The scheme developed for warm-air heating systems makes use of the same kind of tank. A housing is built around the tank, from which radiate the supply ducts to the registers in the rooms. The return air ducts from the house are connected back to the tank housing. An automobile-radiator type of unit heater is mounted within the housing with its flow and return connections joined to the top and bottom of the hot water storage tank. The fan on the unit heater is controlled by the house thermostat, which causes the desired day and night temperatures to be maintained in the rooms.

Because a fan is used to circulate the warm air, the effect of a fan-furnace system is obtained, and it is possible to use small ducts and of such shapes as will accommodate themselves architecturally to the structure of the house, which of course cannot usually be done with warm air where the circulation is solely by gravity.

Domestic Hot Water Heaters

The storage principle for using electricity at off-peak periods is also applied to domestic hot water heaters. Installations of this type of electrical heating have been made in many houses in the middle west during the past four years.

HEAT EQUIVALENTS OF ELECTRICITY

Fundamental Equations

The relation between electrical energy and heat and power is given by the following equations:

1 horsepower = 746 watts.
= 33,000 ft. lb. per minute.
1 B.t.u. = 777.64 ft. lb.
1 horsepower-hour $= \frac{33{,}000 \times 60}{777.64} = 2{,}546$ B.t.u. per hour.
1 watt-hour $= \frac{2{,}546}{746} = 3.415$ B.t.u. per hour.
1 kilowatt (kw) = 1,000 watts.
$= \frac{3{,}415}{160} = 21.3$ sq. ft. of hot water radiation based on a heat emission of 160 B.t.u. per square foot.
$= \frac{3{,}415}{240} = 14.2$ sq. ft. equivalent of steam radiation, based on a heat emission of 240 B.t.u. per square foot.

Efficiency

The efficiency of electricity in direct heaters is 100 per cent. There is only a small loss due to transmission through the wiring system. The effective use of insulation on heat-storing water tanks as used in indirect electrical heating reduces the radiation losses practically to a negligible amount. The efficiency of electricity as a heating agent, then, is a maximum.

CHAPTER 14

CHIMNEYS

Natural, Forced and Induced Draft; Theoretical and Available Draft; Friction Losses; Chimneys for Coal, Oil and Gas Fuels; Details of Construction; Underwriters' Rules.

THE purpose of a chimney is to produce the required draft as well as to carry off the products of combustion and to discharge them so that they will not be harmful or annoying.

DRAFT

The draft required where *natural draft* is employed is equal to the *sum* of the following items:

1. That required to overcome the friction and to produce the velocity of the air at the entrance to the furnace.
2. That necessary to force the air through the fuel bed (if any).
3. That necessary to produce the velocity and to overcome the friction of the products of combustion in their passage through the heat absorbing surfaces.
4. That necessary to produce the velocity and to overcome the friction of the products of combustion in their passage through the breeching, from the heater to the chimney.
5. That necessary to produce the velocity and to overcome the friction of the products of combustion in their passage through the chimney itself.

The draft required where *forced draft* is employed is the sum of items 3, 4 and 5; items 1 and 2 usually being taken care of by the forced draft apparatus.

When *induced draft* is employed the entire draft required is generally taken care of by the induced draft apparatus.

In the case of either forced or induced draft any part of the required draft may be taken care of by the chimney and the remainder by the apparatus, but the exact conditions to be met in this respect should be known and the chimney should be proportioned accordingly.

The combination of natural and mechanical draft is frequently used, especially where loads are quite irregular, so that the plant may be run on natural draft during light loads and on mechanical draft during peak-loads, only. This combination also affords a factor of safety against breakdowns in the mechanical draft equipment, since at least a partial load may always be carried on natural draft.

Draft measurement is usually in inches of water; by which is meant the static head of water (in inches) corresponding to the difference in pressure between any point in the heater, breeching or chimney, at which the draft is being measured, and the pressure of the surrounding atmosphere.

One inch of draft is equivalent to 5.2 lb. per square foot of pressure difference.

Theoretical Draft

The theoretical draft of a chimney is the hypothetical draft that would be produced if the chimney were completely heated and filled with the normal gases of combustion, at the average temperature for which the chimney was designed, and then the flow of these gases was suddenly stopped. This theoretical draft can never be attained in practice, but it is the basis of all scientific chimney design.

The general formula for the theoretical draft of a chimney, with all observable factors taken into account, is expressed by equation (1):

$$D_t = 6.43\, H\, P_o \left(\frac{W_o}{T_o} - \frac{W_g}{T_c} \right) \tag{1}$$

where

D_t = theoretical draft in inches of water.
H = height of the chimney above grate bars, in feet.
P_o = pressure of the atmosphere in pounds per square inch.
W_o = weight of air (at 32 deg. fahr.) in pounds per cubic foot.
W_g = weight of the flue gas (at 32 deg. fahr.) in pounds per cubic foot.
T_o = absolute temperature of the air in deg. fahr.
T_c = average, absolute temperature of the gases in the chimney in deg. fahr.

For an atmospheric pressure of 14.7 lb. and a weight of air equal to the weight of the flue gases (at 32 deg. fahr.) of 0.08071 lb. per cubic foot this formula becomes:

$$D_n = 7.63 \left(\frac{1}{T_o} - \frac{1}{T_c} \right) \tag{2}$$

where

D_n = the normal theoretical draft per foot of height of chimney under usual atmospheric conditions at sea level.

For a temperature of 0 deg. fahr. outside and an average temperature of 600 deg. fahr. in the chimney this reduces to 0.0094 in. of draft per foot of chimney height.

The correction factor for changes in atmospheric pressure, ranges from 68 per cent at 10 lb. pressure to 100 per cent at 14.7 lb. pressure, in direct proportions to the pressure.

The corrections for different densities of flue gas are given in Table 1.

TABLE 1. CORRECTIONS IN INCHES OF WATER PER FOOT OF CHIMNEY TO BE DEDUCTED FROM THE THEORETICAL DRAFT FOR OTHER THAN A 0.08071 LB. PER CUBIC FOOT (AT 32 DEG. FAHR.) DENSITY OF FLUE GAS

DENSITY OF FLUE GAS IN POUNDS PER CUBIC FOOT AT 32 DEG. FAHR.	TEMPERATURE OF FLUE GAS—DEG. FAHR.		
	400	600	800
0.08071	....	....	....
0.0820	0.00014	0.00011	0.00009
0.0830	0.00025	0.00020	0.00017
0.0840	0.00036	0.00030	0.00025
0.0855	0.00053	0.00043	0.00036

Available Draft

The available draft of a chimney is the theoretical draft after deducting the various losses back to the point of reference, such as at the base of the chimney or the furnace of the boiler. Ordinarily the point at which the available draft is measured is in the furnace directly above the fuel bed.

The losses which must be deducted from the theoretical to obtain the available draft at this point are the velocity and friction losses in the chimney, breeching and boiler.

The loss due to velocity of the flue gases in the chimney is expressed by equation (3):

$$D_{cv} = 0.1185 \frac{V_c^2}{T_c} = 0.193 \frac{Q^2}{D^4 T_c} = 0.0001222 \frac{W^2 T_c}{D^4} \qquad (3)$$

where

D_{cv} = loss of draft due to velocity in the chimney.
V_c = velocity of the chimney gases in feet per second.
Q = cubic feet of gas flowing per second.
D = diameter of a circular chimney in feet.
W = weight of gases flowing in pounds per second.

All for a flue gas and air weight of 0.08071 lb. per cubic foot (at 32 deg. fahr.) and an atmospheric pressure of 14.7 lb.

The correction factor for different weights of flue gas runs from 100 per cent at a weight of 0.08071 lb. per cubic foot (at 32 deg. fahr.) to 109 per cent at a weight of 0.088 lb. per cubic foot in direct proportion to the flue-gas weight.

Equation (3) gives the loss due to velocity in the chimney in terms of the velocity, the quantity and the weight of the gases flowing, so that this loss may be figured from either of these factors which may be known.

The loss of draft due to the friction of the gases in the chimney is expressed by equation (4):

$$D_{cf} = 0.0076 \frac{V_c^2 L}{T_c D} = 0.0123 \frac{Q^2 L}{T_c D^5} = 0.0000078 \frac{W^2 T_c L}{D^5} \qquad (4)$$

where

D_{cf} = loss in draft due to friction in the chimney.
L = length of chimney (in feet) through which the gases pass; all for the standard condition heretofore specified. It will be noted that equation (4) also gives the loss in terms of the velocity, quantity and weight of gases flowing.

Equation (4) is for circular sections. For square sections the friction loss is approximately 62 per cent of that for circular section of a diameter equal to the width of the square when handling the same weight of gases per second.

The loss of draft in the breeching is expressed by equation (5):

$$D_b = 0.000955 \frac{W^2}{d^5} \qquad (5)$$

where

D_b = loss of draft in the breeching per foot of length and d = the width of the breeching in feet; all on the following basis: flue-gas temperature of 600 deg. fahr. a flue-gas density of 0.08071 lb. per cubic foot (at 32 deg.) coefficient of friction —0.016, standard atmospheric pressure and ratio of height to width of cross-section of a rectangular breeching of 2 to 1.

The correction factors for different atmospheric pressures and different flue-gas densities are the same as given for the losses in the chimney.

The correction factor for different flue-gas temperatures ranges from 0.8 at 400 deg. to 1.2 at 800 deg. based on the same weight of gas flowing per second.

The loss of draft in the turns of the breeching, including one right angle turn where the gases pass from the boiler to the breeching and another where they pass from the breeching to the chimney, is expressed in inches of water per right angle turn by equation (6):

$$D_{\mathrm{bt}} = 0.0013 \frac{W^2 T_{\mathrm{c}}}{A^2 W_{\mathrm{g}}} \tag{6}$$

where

A = area of breeching in square feet.

The loss of draft through the boilers varies very materially with the size and type of boiler, number of passes, sizes of tubes, etc., but may be taken from Table 2.

TABLE 2. AVERAGE FRICTION LOSS OF FLUE GASES IN PASSING THROUGH BOILERS

PER CENT RATING	100	150	200	250	300
Loss, Inches, Water	0.1 to 0.3	0.2 to 0.6	0.3 to 0.9	0.5 to 1.4	0.7 to 1.9

The loss of draft through the fuel bed or the force of draft necessary to burn different grades and sizes of coal at different rates of combustion may be taken from Fig. 2, p. 207 of Chapter 10, Heating by Coal.

By use of Tables 1 and 2 and equations (1) to (6) inclusive, the theoretical draft and the available draft of any chimney may be calculated under any given set of conditions.

The quantity of gases to be handled is quite variable, depending upon the fuel and the proportion of air used.

The theoretical amount of air required per pound of coal is approximately 12 lb. Fifty per cent excess air is generally allowed, which means that 19 lb. of flue gas may be used per pound of coal burned. The pounds of coal burned per horsepower developed will depend upon the efficiency of the boiler plant but will usually fall between four and five.

The horsepower rating of a chimney is usually a fallacy, except for the smaller plants operating under standard conditions for which the horsepower ratings of the chimney may have been computed. The horsepower capacity of a chimney depends not only upon the many variables already referred to, but also upon the efficiency of the boiler plant, the fuel used and the rate of combustion required to develop the required output.

For instance, a chimney which would produce 1 in. of available draft under a load of 100 hp. in a plant using 4 lb. of coal per horsepower, with a combustion rate of 30 lb. of anthracite pea coal per square foot of grate, would prove entirely inadequate for a 100 hp. load on a boiler plant using 5 lb. of No. 3 buckwheat coal per horsepower at the same combustion rate.

While, as can readily be seen, this method of proportioning chimneys according to horsepower is very approximate, it is frequently used with a fair degree of safety for small plants operating under ordinary conditions.

Low-pressure heating plant chimneys of moderate capacities may be taken from Table 3 or the curves in Fig. 1 with very satisfactory results.

According to their height, heating plant chimneys are divided into three classes, the erratic, uncertain and reliable. Chimneys less than 36 ft. high are erratic in their action. The head produced by such a low height is so small that the least unfavorable conditions or interference practically put the chimney out of commission.

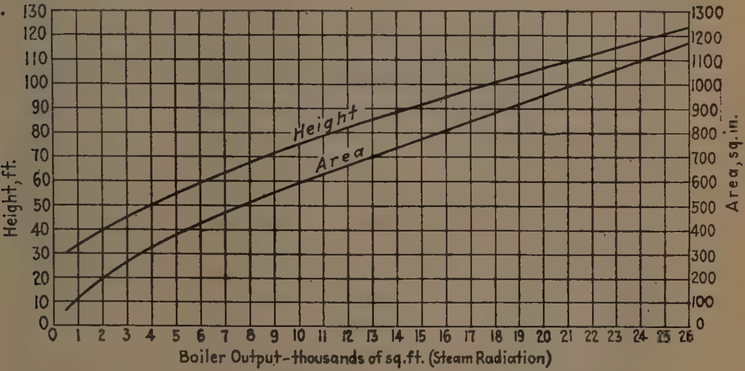


FIG. 1. CHART FOR DETERMINING CHIMNEY SIZE FOR LOW-PRESSURE HEATING PLANTS

Note 1.—It is impossible to make a rule for chimney dimensions which would apply to all boilers, but it will be found that in general all heating boilers when burning any coal except smallest sizes will deliver more than the output shown at the bottom of the chart, Fig. 1, with the corresponding chimney dimensions, during the period when the boiler is likely to be in operation.

Note 2.—It is recommended that the manufacturer of the boiler be consulted in the case of exceptional boilers or where chimney dimensions are less than shown on chart for any given continuous output.

Note 3.—For battery installations the area of chimney is generally taken two-thirds to three-fourths the sum of the areas required for the same number of single boilers. The height is increased 5 to 15 ft. above the single-boiler chimney height in order to compensate for additional turns and damper leakage.

Note 4.—Chimneys for oil-fired boilers may usually be taken 75 per cent of height and area of chimney for same output with solid fuel, except that in cases where the possible change to coal is contemplated the chimneys should be selected as for solid fuel.

Note 5.—For gas-fired boilers the chimney dimensions may be selected from Fig. 1, but do not have to supply draft to move the products of combustion through the boiler or to supply air to the boiler. They serve only to remove the products of combustion from the boiler room. The draft diverter supplied with all gas boilers effectively limits the draft at the boiler outlet and also prevents a reversal of direction of flow in the chimney from effecting boiler operation.

At best the head produced by chimneys up to 64 ft. in height is so small that the draft is frequently affected by surrounding conditions making the draft a doubtful one. Chimneys over 64 ft. in height are not usually so affected, because as a rule the chimney is designed by an engineer and must be well built to sustain such a heavy load and the height is such as to produce considerable draft to offset unfavorable weather conditions, etc. Chimneys in this class produce about 0.00945 in. of theoretical draft per foot of height in zero weather with 600 deg. in the stack.

TABLE 3. CHIMNEY SIZES FOR LOW-PRESSURE HEATING BOILERS AND WARM AIR FURNACES

WARM AIR FURNACE CAPACITY IN LEADER PIPE SQ. IN.	STEAM BOILER CAPACITY SQ. FT. OF RADIATION	HOT WATER HEATER CAPACITY SQ. FT. OF RADIATION	NOMINAL DIMENSIONS OF FIRE CLAY LINING IN.	RECTANGULAR FLUE			ROUND FLUE		
				Actual Inside Dimensions of Fire Clay Lining In.	Actual Area Sq. In.	Effective Area Sq. In.	Inside Diameter of Lining In.	Actual Area Sq. In.	Height in Ft. from Grate
790	590	973	8½x13	7x11½	81	70			As height necessary is dependent upon the draft requirements of the varying designs, these factors should be known before height can be accurately determined.
1000	690	1140					10	79	
	900	1490	13x13	11¼x11¼	127	99			
	900	1490	8½x18	6¾x16¼	110	100			
	1100	1820					12	113	
	1700	2800	13x18	11¼x16¼	183	156			
	1940	3200					15	177	
	2130	3520	18x18	15¾x15¾	248	195			
	2480	4090	20x20	17¼x17¼	298	234			
	3150	5200					18	254	
	4300	7100					20	314	
	4600	7590	20x24	17x21	357	278			
	5000	8250	24x24	21x21	441				
	5570	9190		24x24[a]	576	380			
	5580	9200					22	380	
	6980	11500					24	452	
	7270	12000		24x28[a]	672	468			
	8700	14400		28x28[a]	784	531			
	9380	15500					27	573	
	10150	16750		30x30[a]	900	616			
	10470	17250		28x32[a]	896	635			
	11800	19500					30	707	
	14700	24300					33	855	
	17900	29500					36	1018	

[a] Dimensions are for unlined rectangular flues.

Chimneys recommended for larger boilers 15 to 250 hp. may be proportioned in accordance with the report made by a joint Committee of the *American Boiler Manufacturers Association* and *Stoker Manufacturers Association* and approved by these organizations. The sizes are given in Tables 4, 5 and 6. Chimneys for still greater horsepowers are given in Tables 5 and 6.

CHIMNEYS FOR OIL FUEL[1]

The requirements for stacks for oil fuels are entirely different from those connected to coal-fired boilers, as there are certain losses through the boiler proper that are eliminated. Gas temperatures entering the stacks are lower for a given capacity, and the volume of gas is less than with coal. The cross-sectional area of the stack may therefore be less. In most instances this may safely be taken as 60 per cent of the area that would be furnished for coal-fired boilers. In determining the height, care must be taken to design a stack that will give a sufficient draft for the maximum requirements of the boiler, but no more. In this way the

---

[1] From Marks' Mechanical Engineers Handbook.

TABLE 4. DRAFT LOSSES WITH FORCED DRAFT STOKERS AND CORRESPONDING HEIGHT OF STACK FOR AVERAGE INSTALLATIONS (SEA LEVEL)[a]

	RATING—PER CENT				
	100	150	200	250	300
Furnace Draft[b]	0.15	0.15	0.15	0.15	0.15
Friction Loss (Boiler)[c]	0.18	0.4	0.65	0.9	1.20
Friction Loss (Breeching)[d]	0.10	0.10	0.10	0.10	0.10
Total Draft Required	0.43	0.65	0.90	1.15	1.45
Height of Stack (Ft.)	80	112	145	178	220

[a] For boilers from 15 to 250 hp.

[b] Allow 0.15 in. for forced draft and 0.35 in. or higher, depending on rate of combustion and fuel used, for natural draft.

[c] Friction loss through boiler varies according to construction.

[d] Allow 0.05 in. for each right angle bend and 0.1 in. per 100 ft. of length.

TABLE 5. DIAMETER OF CHIMNEY IN INCHES FOR HORIZONTAL RETURN TUBULAR BOILERS[a]

NOMINAL HORSEPOWER	RATING—PER CENT		
	100	150	200
15	13	14	17
20	14	16	18
25	16	18	20
30	17	19	21
35	18	20	22
40	19	21	23
50	20	23	25
60	21	24	27
75	23	26	29
90	25	28	31
100	26	29	33
115	27	31	34
125	28	32	35
150	30	34	38
175	32	36	40
200	33	38	43
210	34	38	44
225	35	40	45
250	36	41	47

[a] The figures in this table are based on the following assumptions:

Rating	100%	150%	200%
Efficiency	65%	65%	63%
CO_2	8%	9%	10%
Stack Temp, deg. fahr.	450	500	550
Pounds of gas	85	77	73

efficiency is safeguarded, and the danger of a draft such as to pull through too large an excess of air is eliminated.

Table 9, adapted from a similar table calculated by C. R. Weymouth (*Trans. A. S. M. E.*, Vol. 34, 1912) and based on actual test data, will be found to give satisfactory results under the assumed conditions as given for stacks with oil-burning boilers.

CHIMNEYS FOR GAS APPLIANCES

The burning of gas differs from the burning of coal in that the force which supplies the air for combustion of the gas comes largely from the pressure of the gas in the supply pipe, whereas air is supplied to a bed of burning coal by the force of the chimney draft. If, with a coal-burning boiler, the draft is poor, or if the chimney is stopped, the fire is smothered and the combustion rate reduced. Such a condition on a gas boiler or furnace would interfere with the combustion of the gas, but the gas would continue to pass to the burners and the resulting incomplete combustion would produce a dangerous condition. In order to prevent incomplete combustion from insufficient draft, all gas-fired boilers and furnaces should have a back-draft diverter in the flue connection to the chimney.

A study of the drawing of a typical back draft diverter will make it plain that a stoppage in the chimney will cause the combustion products to come out into the boiler room, but there will be no interference with the complete combustion of the gas. Another feature in the construction of the back-draft diverter is that a down draft from the chimney will have practically no effect upon the combustion of the gas, due to the baffle deflecting the draft into the boiler room.

TABLE 6. HEIGHT OF STACK IN FEET FOR HORIZONTAL RETURN TUBULAR BOILERS (SEA LEVEL AND 60 DEG. FAHR. OUTSIDE TEMPERATURE)[a]

NOMINAL HORSEPOWER	DRAFT AT BASE OF STACK, INCHES	RATING—PER CENT		
		100	150	200
15	0.12	21	22	25
20	0.15	26	28	30
25	0.20	35	37	41
30	0.25	43	46	51
35	0.30	52	56	61
40	0.35	60	65	71
50	0.40	69	74	81
60	0.45	78	84	91
75	0.50	86	93	101
90	0.55	95	102	111
100	0.60	104	112	122
115	0.65	112	121	132

[a] Friction loss in stack assumed 0.1 in. per 100 ft. See also Note a, Table 5.

As is the case with the complete combustion of almost all fuels, the products of combustion for gas are carbon dioxide (CO_2) and water vapor with just a trace of sulphur trioxide (SO_3). Sulphur usually burns to the trioxide in the presence of an iron oxide catalyst. The volume of water vapor in the flue products is about twice the volume of the carbon dioxide when coke oven or natural gas is burned. Because of the large quantity of water vapor which is formed by the burning of gas, it is quite important that all gas-fired central heating plants be connected to a chimney having a good draft. Lack of chimney draft causes stagnation of the products of combustion in the chimney and results in the condensation of a large amount of the water vapor. A good chimney draft draws air into the chimney through the openings in the back-draft

TABLE 7. AVAILABLE DRAFT FOR 100 FT. STEEL STACKS OF DIFFERENT DIAMETERS[a]

Based on a stack temperature of 500 deg. fahr.[b] and 100 lb. of gas per horsepower

For other heights of stack, multiply draft by height ÷ 100

HORSEPOWER	DIAMETER OF STACK IN INCHES														
	36	42	48	54	60	66	72	78	84	96	108	114	120	132	144
200	0.55	0.62													
400	0.21	0.46	0.56	0.61											
600		0.19	0.42	0.53	0.59										
800			0.23	0.43	0.52	0.58	0.61	0.63							
1000				0.29	0.45	0.53	0.58	0.61	0.63						
1200					0.35	0.47	0.54	0.58	0.61	0.64					
1600						0.31	0.43	0.52	0.56	0.62	0.64	0.65	0.65		
2000								0.43	0.50	0.59	0.62	0.63	0.64		
2500									0.41	0.54	0.60	0.61	0.63		
3000										0.48	0.56	0.59	0.61	0.63	0.64
3500										0.40	0.52	0.56	0.58	0.62	0.64
4000											0.48	0.52	0.56	0.60	0.62
4500											0.43	0.49	0.55	0.58	0.60
5000												0.44	0.49	0.56	0.60

[a] Data from Marks' Mechanical Engineers Handbook.

[b] For other stack temperatures add or deduct before multiplying by height ÷ 100, as follows:

For 750 deg. fahr. add 0.17 in.	For 550 deg. fahr. add 0.04 in.
For 700 deg. fahr. add 0.14 in.	For 450 deg. fahr. deduct 0.04 in.
For 650 deg. fahr. add 0.11 in.	For 400 deg. fahr. deduct 0.08 in.
For 600 deg. fahr. add 0.08 in.	For 350 deg. fahr. deduct 0.14 in.

TABLE 8. STACK SIZES BY KENT'S FORMULA

(Assuming 5 lb. of coal per horsepower per hour)

DIAM IN	AREA SQ. FT	HEIGHT OF STACK IN FEET										SIDE OF EQUIVALENT SQUARE STACK INCHES	DIAM INCHES
		50	60	80	100	125	150	175	200	225	250		
		COMMERCIAL HORSEPOWER											
33	5.94	106	115	133	149							30	33
36	7.07	129	141	163	182							32	36
39	8.30	155	169	196	219	245						35	39
42	9.62	183	200	231	258	289	316					38	42
48	12.57	246	269	311	348	389	426	460				43	48
54	15.90	318	348	402	449	503	551	595				48	54
60	19.64	400	437	505	565	632	692	748				54	60
66	23.76	490	537	620	694	776	849	918				59	66
72	28.27	591	646	747	835	934	1023	1105				64	72
78	33.18	700	766	885	990	1107	1212	1310				70	78
84	38.48	818	896	1035	1157	1294	1418	1531				75	84
90	44.18				1338	1496	1639	1770	1893	2008	2116	80	90
96	50.27				1532	1713	1876	2027	2167	2298	2423	86	96
102	56.75				1739	1944	2130	2300	2459	2609	2750	91	102
108	63.62				1959	2190	2392	2592	2770	2939	3098	96	108
114	70.88				2192	2451	2685	2900	3100	3288	3466	101	114
120	78.54				2438	2726	2986	3226	3448	3657	3855	107	120
126	86.59				2697	3016	3303	3568	3814	4046	4265	112	126
132	95.03				2970	3321	3637	3929	4200	4455	4696	117	132
144	113.10				3554	3973	4352	4701	5026	5331	5618	128	144
156	132.73				4190	4684	5131	5542	5925	6285	6624	138	156
168	153.94				4878	5454	5974	6454	6899	7318	7713	150	168

diverter, lowers the dew-point of the mixture, and reduces the tendency of the water vapor to condense.

A chimney for a gas-fired boiler or furnace should be constructed in accordance with the principles applicable to other boilers. Where the wall forming a smoke flue is made up of less than an 8 in. thickness of brick, concrete or stone, a burnt fire clay flue tile lining should be used. Care should be used that the lengths of flue tile meet properly with no openings at the joints. Cement mortar should be used for the entire chimney.

TABLE 9. MAXIMUM CAPACITIES OF STACKS IN BOILER HORSEPOWER FOR OIL FUEL[a]

STACK DIAMETER INCHES	HEIGHT IN FEET ABOVE BOILER ROOM FLOOR					
	80	90	100	120	140	160
33	161	206	233	270	306	315
36	208	253	295	331	363	387
39	251	303	343	399	488	467
42	295	359	403	474	521	557
48	399	486	551	645	713	760
54	519	634	720	847	933	1000
60	657	800	913	1073	1193	1280
66	813	993	1133	1333	1480	1593
72	980	1206	1373	1620	1807	1940
84	1373	1587	1933	2293	2560	2767
96	1833	2260	2587	3087	3453	3740
108	2367	2920	3347	4000	4483	4867
120	3060	3660	4207	5040	5660	6160

[a] Figures represent nominal rated horsepower; sizes as given are based on 50 per cent overloads and centrally located stacks, short direct flues and ordinary operating efficiencies.

Correction for altitude may be made according to Table 10.

TABLE 10. CORRECTION FACTORS FOR ALTITUDE

HEIGHT ABOVE SEA LEVEL FEET	RATIO INCREASE IN DIAMETER	RATIO INCREASE IN HEIGHT
0	1.000	1.000
1,000	1.015	1.079
2,000	1.030	1.164
4,000	1.063	1.356
6,000	1.096	1.580
8,000	1.130	1.841
10,000	1.165	2.144

Table 11 gives the minimum cross-sectional diameters of round chimneys (in inches) for various amounts of heat supplied to the appliance, and for various chimney heights. This is in accordance with *American Gas Association* recommendations.

The flue connections from a gas-fired boiler or furnace to the chimney should be of a non-corrosive material. In localities where the price of gas requires the use of highly efficient appliances, the material used for the flue connection not only should be resistant to the corrosion of water, but should resist the corrosion of dilute solutions of sulphur trioxide in

Table 11. Minimum Round Chimney Diameters for Gas Appliances (Inches)

Height of Chimney Feet	Gas Consumption in Thousands of B.T.U. per Hour								
	100	200	300	400	500	750	1000	1500	2000
20	4.50	5.70	6.60	7.30	8.00	9.40	10.50	12.35	13.85
40	4.25	5.50	6.40	7.10	7.80	9.15	10.25	12.10	13.55
60	4.10	5.35	6.20	6.90	7.60	8.90	10.00	11.85	13.25
80	4.00	5.20	6.00	6.70	7.35	8.65	9.75	11.50	12.85
100	3.90	5.00	5.90	6.50	7.20	8.40	9.40	11.00	12.40

water. Sheet aluminum, as well as some other materials, seems to serve this purpose very well.

CONSTRUCTION OF CHIMNEYS

For general data on the construction of chimneys reference should be made to the Standard Ordinance for Chimney Construction of the *National Board of Fire Underwriters.* Briefly summarized, these provisions are as follows for heating boilers and furnaces:

The construction, location, height and area of the chimney to which a heating boiler or warm-air furnace is connected affect the operation of the entire heating system. Most residence chimneys are built of brick and may be either lined or unlined, but in either case the *walls must be air-tight* and there should be *only one smoke opening* into the chimney. Cleanout, if provided, must be *absolutely air-tight* when closed.

The walls of brick chimneys shall be not less than 3¾ in. thick (width of a standard size brick) and shall be lined with fire-clay flue lining. Fire-clay flue linings shall be manufactured from suitable refractory clay, either natural or compounded, and shall be adapted to withstand high temperatures and the action of flue gases. They shall be of standard commercial thickness, but not less than ¾ in. All fire-clay flue linings shall meet the standard specification of the *Eastern Clay Products Association.* The flue sections shall be set in special mortar, and shall have the joints struck smooth on the inside. The masonry shall be built around each section of lining as it is placed, and all spaces between masonry and linings shall be completely filled with mortar. No broken flue lining shall be used. Flue lining shall start at least 4 in. below the bottom of smoke-pipe intakes of flues, and shall be continued the entire heights of the flues and project at least 4 in. above chimney top to allow for a 2 in. projection of lining. The wash or splay shall be formed of a rich cement mortar. To improve the draft the wash surface should be concave wherever practical.

Flue lining may be omitted in brick chimneys, provided the walls of the chimneys are not less than 8 in. thick, and that the inner course shall be a refractory clay brick. All brickwork shall be laid in spread mortar, with all joints push-filled. Exposed joints both inside and outside shall be struck smooth. No plaster lining shall be permitted.

Chimneys shall extend at least 3 ft. above flat roofs and 2 ft. above the ridges of peak roofs when such flat roofs or peaks are within 30 ft. of the chimney. The chimney shall be high enough so that the wind from any direction shall not strike the top of the chimney from an angle above the horizontal. The chimney shall be properly capped with stone, terra cotta, concrete, cast iron, or other approved material; but no such cap or coping shall decrease the flue area.

There shall be but one connection to the flue to which the boiler or furnace smoke-pipe is attached. The boiler or furnace smoke-pipe shall be thoroughly grouted into the chimney and shall not project beyond the inner surface of the flue lining.

The size or area of flue lining or of brick flue for warm-air furnaces depends on height of chimney and capacity of heating system. For chimneys not less than 35 ft. in height above grate line, the net internal dimensions of lining should be at least 7 x 11½ in. for a total leader pipe area up to 790 sq. in. Above 790 and up to 1,000 sq. in. of leader pipe area the lining should be at least 11¼ x 11¼ in. inside. In case of brick flues not less than 35 ft. in height with no linings, the internal dimensions should be at least 8 x 12 in. up to 790 sq. in. of leader area, and at least 12 x 12 in. for leader capacities up to 1,000 sq. in. Chimneys under 35 ft. in height are unsatisfactory in operation and hence should be avoided.

SMOKE TEST

The chimney flue must be smoke tight and shall be subjected to a smoke test by the mason contractor in the presence of the architect or his representative, after the mortar has thoroughly hardened.

The method of conducting this test shall be as follows: With a good fire in the boiler or furnace, or in the base of the chimney, put about a square yard of tar paper on the fire. As soon as smoke appears at the top of the chimney close the top of the flue with a piece of old carpet or wet newspapers held down by a weighted board. Keep the tar paper burning in the firepot for five minutes. The architect or his representative shall sign an acceptance in triplicate, stating that the chimney was tight under the foregoing test, and shall give one copy to the mason contractor, one copy to the heating contractor and one copy to the owner.

CHAPTER 15

BOILERS FOR STEAM AND HOT WATER HEATING

Duty of Boiler; Boiler Selection; Boiler Ratings; Types of Boilers; Boiler Troubles; Operating Conditions; Burning Anthracite and Bituminous Coal; Pick-up Load; Hot Water Supply Boilers.

THE function of a boiler is to deliver a specified quantity of heat in the form of dry steam or hot water at its outlet.

If the boiler is equipped with automatic temperature or pressure control, this control should actuate dampers or other means for governing the rate of combustion within certain limits. When equipped with devices intended to accomplish a definite combustion result, as, for example, to burn bituminous coal smokelessly, the boilers should accomplish this without undue attention.

The most important conditions affecting the operation of the boiler to be met, if it is to accomplish its purpose, are as follows:

1. There must be a chimney or other means of draft of adequate capacity.
2. The fuel used must be as good as that contemplated when the boiler was selected.
3. The quality of attention and its frequency must equal that contemplated when the boiler was selected.
4. The piping and heat-emitting surfaces connected to the boiler must function properly.
5. The water in the system must be in favorable condition, free from grease and other foreign matter.

BOILER SELECTION

Ordinarily, especially in residence heating and in other small installations, the information upon which the boiler is selected is meager. This information usually covers the heat output of radiators under normal temperatures, the kind of fuel, whether anthracite or bituminous coal, oil or gas, and in a few cases the amount of heat-emitting surface in the piping. Successful selection of a boiler based only upon this information requires good judgment and the boiler usually must be selected large enough to deliver the required quantity of heat under the most adverse conditions of attention, fuel, draft, etc.

A boiler usually is selected from the manufacturer's catalog with a rating 80 to 100 per cent in excess of the manufacturer's rating expressed in equivalent square feet of direct radiation.

The following items taken from the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS CODE OF MINIMUM REQUIREMENTS FOR THE HEATING AND VENTILATION OF BUILDINGS cover information which should be available for intelligent boiler selection:

1. The estimated heat emission in B.t.u. per hour of the connected radiation (direct, indirect or blast) to be installed, as previously determined by calculations given in Chapter 2 of THE GUIDE.

2. The estimated maximum heat in B.t.u. per hour required to supply water heaters or other apparatus to be connected to the boiler.

3. The estimated heat emission in B.t.u. per hour of the piping connecting the radiation and other apparatus to the boiler.

4. The estimated increase in the normal load in B.t.u. per hour due to starting up cold radiation, etc. This percentage of increase to be based on the sum of items (1), (2) and (3) shall not be assumed less than the following:

Sum of (1), (2) and (3):

Up to 100,000 B.t.u. add 65 per cent.
100,000 to 200,000 B.t.u. add 60 per cent.
200,000 to 600,000 B.t.u. add 55 per cent.
600,000 to 1,200,000 B.t.u. add 50 per cent.
1,200,000 to 1,800,000 B.t.u. add 45 per cent.
Above 1,800,000 B.t.u. add 40 per cent.

Other things to be considered are:

5. The kind and amount of attention available. Attention is least skillful and least frequent for owner-operated residence installations and generally increases in skill as well as frequency as size of boiler increases. Local fuels and types of firing service must be considered carefully in this connection.

6. The kind of fuel to be used, including size and characteristics.

7. Size and height of the available chimney.

With definite requirements as given by items 1 to 4 available, the boiler performance information, obtained according to AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS CODE NO. 3—PERFORMANCE TEST CODE FOR STEAM HEATING SOLID FUEL BOILERS, can be used for selection of the proper size of solid fuel burning boiler.

Other Factors in Selection of Boiler

As it will usually be found that several boilers will meet the specifications, the final selection of the boiler will be effected by other considerations as follows:

(*a*) Dimensions of boiler; (*b*) Height of water line; (*c*) Durability under service; (*d*) Convenience in firing and cleaning; (*e*) Type of controls; (*f*) Adaptability to changes in fuel and kind of attention; (*g*) The output required during the greater part of the season.

In large installations the use of several smaller boiler units instead of one larger one will obtain greater flexibility and economy by permitting the operation of a required number of units according to heat requirements at the best operating efficiency.

Numerical Value of Maximum Hourly Output

Experience with gas-fired boilers, which are rated on B.t.u. output and which can only slightly exceed the rated output, but which require no chimney draft, has shown that a continuous output capacity of 25 per cent in excess of the normal heat loss of radiation, plus piping, is ample for all direct radiator installations. This corresponds to an output of 40 to 60 per cent in excess of the normal heat loss of the radiation, depending upon the proportion of piping to radiation.

Gas-fired boilers rated according to the *American Gas Association* method and having, therefore, *A.G.A. Ratings* are selected in the majority of direct radiator installations, according to the table of selection factors given in Chapter 11, page 229.

Upon the basis of gas-fired boiler experience, a coal-fired boiler which could deliver a continuous average output of 25 per cent in excess of radiation and piping would be amply large for any job. This is true for an oil-fired boiler, provided the known output of the combination of boiler, burner, and chimney is used.

Where test data are not available for the contemplated combination of boiler and oil burner, economical performance may be obtained by selecting a boiler in which the heat absorbed per square foot of boiler heating surface at the maximum continuous output is approximately 4,000 B.t.u. per hour. It should be ascertained that the burner selected has sufficient combustion space to permit the burning of the required quantity of the available oil fuel.

In the case of coal-fired boilers, however, it is necessary to make additional allowance for the following conditions not due to boiler construction which may obtain at the time when the maximum pick-up load occurs. (*a*) insufficient draft; (*b*) poor quality of fuel; (*c*) fuel bed not in good condition; (*d*) inferior quality of attention; (*e*) necessity of firing a charge of fuel that will last for a long period; (*f*) dirty flues.

The conditions (*a*) to (*f*) inclusive, reduce the output obtainable to a point below that which could be obtained under good or normal conditions and necessitate a larger boiler, in order that when the normal output is decreased by the effect of items (*a*) to (*f*) there will still be available a quantity of heat 25 per cent in excess of the radiation-plus-piping loss. Coal-fired boilers, therefore, are usually selected with a maximum continuous output 60 to 80 per cent in excess of the demand of radiation-plus-piping.

For large boiler installations the foregoing percentages in excess of the heat loss of radiation-plus-piping may be reduced to the following:

	Per Cent
School buildings without recirculation of air	50
School buildings with full recirculation of air	25
Buildings with periodical heating only	50
Other large buildings	25

For any boiler selected it is well to determine whether the rate of combustion (fuel burned per square foot of grate per hour) will be required continuously for more than a few hours and whether it is low enough to prevent clinker trouble. With natural draft it is recommended that for *continuous* output (under favorable conditions), with a *minimum of attention*, the combustion rates given in Table 1 be not exceeded.

In the case of boilers having larger grates, better draft and more frequent attention, rates of combustion may be greatly increased over those shown in Table 1.

Selection of Steel Boilers

Manufacturers of steel heating boilers (members of the *American Boiler Manufacturers' Association*) prefer the following method of selection: Select a boiler with published rating (rating determined by heating

TABLE 1. PRACTICAL COMBUSTION RATES FOR RELATIVELY SMALL COAL-FIRED HEATING BOILERS OPERATING ON NATURAL DRAFT OF FROM ¼ IN. TO ½ IN. WATER

SQ. FT. GRATE	KIND OF COAL	LB. OF COAL PER SQ. FT. GRATE PER HOUR
Up to 4	No. 1 Buckwheat Anthracite	3
5 to 9	No. 1 Buckwheat Anthracite	3½
10 " 14	No. 1 Buckwheat Anthracite	4
15 " 19	No. 1 Buckwheat Anthracite	4½
20 " 25	No. 1 Buckwheat Anthracite	5
Up to 9	Anthracite Pea	5
10 to 19	Anthracite Pea	5½
20 " 25	Anthracite Pea	6
Up to 4	Anthracite Nut and Larger	5
5 to 9	Anthracite Nut and Larger	6
10 " 14	Anthracite Nut and Larger	7
15 " 19	Anthracite Nut and Larger	8
20 " 25	Anthracite Nut and Larger	9
Up to 4	Bituminous	4
5 to 14	Bituminous	7
15 and above	Bituminous	10

surface and grate area) corresponding by heating surface to the estimated design load as defined in Section V of the CODE OF MINIMUM REQUIREMENTS, being the sum of items (A), (B) and (C) in Paragraph 1. (This is the same (1), (2) and (3) on page 264 of this chapter.)

BOILER RATINGS

The use of boilers the output of which has been determined in accordance with the boiler testing code No. 3 of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is recommended.

A method sometimes used for estimating the approximate reasonable output of a boiler where more accurate and reliable test data are not available, is as follows:

> The output in B.t.u. is obtained by multiplying together the square feet of grate surface by an assumed rate of combustion (in pounds of coal per square foot of grate per hour) by the B.t.u. value of the fuel (per pound) by the efficiency of the boiler (at the load and rate of combustion assumed).

This gives an approximate rating. For data on rates of combustion, see Table 1, also Chapter 10, Heating by Coal, and Chapter 14, Chimneys.

Ordinary heating boiler efficiencies for normal rate of combustion usually range between 55 per cent and 75 per cent.

Gas-Fired Boiler Ratings

The rating of gas boilers, in contrast to that of coal boilers is a comparatively simple matter. The following conditions of rating established by the *American Gas Association* have been generally accepted:

1. The boiler must deliver rated output without chimney connection.
2. There must be no carbon monoxide formed when the gas pressure in service line is normal, 50 per cent below normal, or 50 per cent above normal.
3. The boiler must have an efficiency of at least 75 per cent at rated output.
4. Gas pressure drop in all valves and fittings must not exceed 1 in. of water.

The maximum B.t.u. input or gas that can be burned may be determined by the manufacturer but is checked by the *American Gas Association* laboratory before being approved. An arbitrary efficiency of 80 per cent is assumed in computing the output rating from the B.t.u. input.

The actual B.t.u. delivered by any gas boiler when burning gas at the rated B.t.u. input will vary from the *A.G.A.* output rating in the direct proportion of the actual efficiency with the gas being burned to the assumed efficiency of 80 per cent.

Oil-Fired Boiler Ratings

The output of a boiler with oil fuel will depend upon the combined efficiency of the boiler and burner and the quantity of oil that can be burned properly within the space provided in the boiler.

Oil burner ratings in use at present have been obtained either from tests with typical burners or have been obtained by multiplying the coal rating by a constant.

Coal boilers converted to oil may have as high or a higher rating and as high or higher efficiency than with coal.

To inaugurate unproved terminology:

Size means physical dimensions, in contradistinction to rating or output.

Rating means the output of the boiler; the work which it performs.

TYPES OF BOILERS

Broadly speaking, three types of boilers are commonly used—sectional, fire-tube and water-tube.

Sectional boilers may be of the rectangular pattern with vertical sections, or of the round pattern with horizontal sections. They are usually constructed of cast iron; and on account of their sectional construction and the usual practice of being shipped knocked down and assembled on the job, they are easily handled through small openings at any stage of construction. Their design also facilitates the removal and replacing of damaged parts as well as an increase of decrease in capacity by the addition or removal of sections.

Cast iron boilers usually are limited to operating pressures of 15 lb. steam or 30 lb. water, excepting when used for hot water supply, in which case the boilers are built for operation at city pressure and are tested at pressures two and one-half times the operating pressure.

Fire-tube boilers may be of the horizontal tubular brickset pattern, the horizontal tubular firebox pattern (with or without supplementary brick setting), the vertical tubular brickset pattern or the vertical tubular firebox pattern.

Fire-tube steel boilers may be built for high or low pressure, but when used for heating with consequent usual low-pressure operation, they generally are built according to the *A. S. M. E. Steel Plate Heating Boiler Code* which limits working pressure to 15 lb. per square inch for steam boilers, or 250 deg. fahr. or 160 lb. per square inch for water boilers. In construction they may be riveted or welded. Where higher operating pressures are required, boilers of the same dimensions as low-pressure boilers can be obtained at a comparatively small increase in cost.

The large water content of this type of boiler provides for heat storage capacity against sudden demands and minimizes water line fluctuations under sudden variations in load. Chimney heights for the larger sizes of fire-tube boilers as specified by the manufacturer generally are lower than for corresponding sizes of cast iron boilers.

Water-tube boilers may be of the horizontal brickset pattern with either horizontal or cross drums, the vertical brickset pattern, the bent or inclined tube brickset pattern, or the self-contained firebox pattern with any one of the above arrangements of tubes.

Water-tube boilers usually are constructed with steel or iron tubes, steel drums and either steel, cast steel or cast iron headers. They heat up and steam rapidly and also lose their heat and steam pressure quickly, since the water content is small.

The principal heating surface, consisting of tubes with the water inside and the heated gases outside, is easy to clean from the inside with hydraulic or pneumatic tube cleaners and from the outside with steam of air jet soot blowers. Water-tube boilers are to be avoided where the water contains large quantities of scale forming material.

Since water-tube boilers usually have limited steam-disengaging area at the water line, it usually is desirable to operate them at comparatively high pressure, and water-tube boilers operated at less than 15 lb. pressure in heating service are and should be, unusual.

SPACE ALLOWANCE FOR BOILERS

Boilers often are placed in quarters which are too cramped for convenient handling of the fire, the coal and the ashes. The space in front of the boilers should be sufficient for firing, stoking, ash removal and cleaning or renewal of flues, and should be at least 3 ft. greater than the length of the boiler firebox.

A space of at least 3 ft. should be allowed on at least one side of every boiler for convenience of erection and for accessibility to the various dampers, cleanouts and trimmings. The space at the rear of the boiler should be ample for the chimney connection and for cleanouts and with large boilers the rear clearance should be at least 3 ft. in width.

The boiler room height should be sufficient for location of boiler accessories and for proper installation of piping. In general the ceiling height for small steam boilers should be at least 3½ ft. above the normal boiler water line. With vapor heating especially the height above the boiler water line is of vital importance.

INSTALLING AND PREPARING BOILERS FOR SERVICE

The directions of the boiler manufacturer always should be read before the assembly or installation of any boiler is started, even though the contractor may be familiar with the boiler. All joints requiring boiler putty or cement, which cannot be reached after assembly is complete, must be finished as the assembly progresses.

Nuts or tie rods of sectional cast iron boilers always must be drawn up and then loosened about one thread to allow for expansion of the boiler when hot. The nuts should be just a little more than hand-tight when the boiler is at its operating temperature.

Flow piping connections should be full size of the manufacturers outlet and preferably should be vertical from the outlets to the maximum height available above the boiler. A large tall outlet pipe and a low outlet velocity are of great value in separating the steam from the water; especially if the boiler has accumulated grease and other foreign matter.

Maximum steam velocities of from 20 to 25 ft. per second at the boiler outlet are recommended.

The outlets from steam boilers should be placed as remotely as possible from the areas of the water surface at which steam separation is most violent.

There is usually some advantage to be obtained with low-pressure steam boilers by installing a large drip connection back to the boiler below the water line, from a point as near as practicable to the steam outlet.

Recommended methods of connecting piping to steam boilers are shown in Chapter 20, Piping for Steam Heating Systems.

WATER LINE IN STEAM BOILERS

Enough water only should be added to heating boilers to keep the water line at the height established by the manufacturer. Raising the water to a higher level may result in carrying over of water with the steam. Water from small steam heating systems should not be lost by leakage or withdrawn to serve as hot water supply as the fresh water required to make up the loss may introduce scale-forming or corrosive matter. On the other hand the occasional addition of new scale-forming water under some conditions may prevent excessive corrosion or pitting of the boiler interior.

CLEANING STEAM BOILERS

The grease used to lubricate the cutting tools during erection of new piping systems serves as a carrier for sand and dirt, with the result that a scum of fine particles and grease accumulates on the surface of the water in all new boilers, while heavier particles may settle to the bottom of the boiler and form sludge. The scum is best removed through an outlet at the surface of the water.

The method given has been used successfully for cleaning new boilers.

The boiler should be blown off within about one week after it has been placed in operation. This blowing off is to remove the unavoidable accumulation of oil, grease, etc. These impurities unless removed have a tendency to cause foaming; preventing the generation of steam and causing an unsteady water line. This blowing off should be done when the boiler is under fire. If one blowing off does not result in a steady water line and a clean water gage, the operation must be repeated and repeated; sometimes requiring the exercising of great patience and persistence.

An approved procedure for blowing off is as follows:

Close all radiator valves and remove the thermostatic members of all return line traps, if there are valves at the boiler, close both the supply and return valves. Remove the damper regulator and plug the opening. Remove the plug at the water line blow-off or provide an equivalent opening and connect a blow-off pipe to the opening, with a gate valve or cock extending this pipe to a suitable drain or out of the basement window, providing that the basement window is lower than the point of connection to the boiler. The blow-off piping should be as large as possible, in any event not smaller than 1 in. in diameter. Many boilers have permanent surface blow-off openings and connections.

With sufficient fire in the boiler to keep the water at the boiling point, turn on the cold water supply enough to cause the water in the boiler to overflow slowly through the blow-off pipe until the surface of the water line is thoroughly skimmed of all oil and grease. One to two hours, generally, is sufficient. At intervals the water supply and blow-off valves may be closed to allow the temperature of the water to be raised.

The best results in skimming a boiler over the top can be obtained by regulating the fire and the water supply in such manner as never to allow the overflowing water completely to fill the surface blow-off pipe. The flow through this pipe should be slow, so that the grease on top of the water will float away and not be forced against the upper inside surface of the metal in the top of the boiler.

When assured that the overflowing water is free from grease, shut off the water supply valve and the gate valve in the overflow pipe and draw the water down to its correct line, using the regular blow-off at the bottom of the boiler, then close the lower blow-off, and using wood as a fuel, raise the steam pressure to at least 12 lb. Then open the lower blow-off cock wide, using care to see that the supply of water has been blown out, but do not have the fuel bed so thick that it will be difficult to dump the grates when all water has been blown from the boiler. Then open all fire and flue doors wide and allow the boiler to cool; close the drain cock; remove the surface blow-off pipe; close the opening, replace the damper regulator, and fill the boiler slowly to the water line. Then open all radiator valves, open the boiler flow and return valves, and if the thermostatic members have been removed from the return line traps, these can be replaced while the boiler is cooling. The fire then can be rekindled and the boiler may be tested for steaming.

On some boilers it may be convenient to make the temporary surface blow-off connections at the safety valve tapping; this is permissible, though it will be necessary to carry a higher water line to accomplish the skimming action. The balance of the operation will be as already described.

In boilers where a large amount of grease is present, it may be desirable to add a quantity of soda ash, which should be boiled in the boiler for at least half an hour before the blowing off operation is started. If soda ash is used it should be purchased from a wholesale drug house or drug store, for package products sold in grocery stores sometimes contain a percentage of soap, which is undesirable for this purpose.

The quantities of soda ash necessary can be determined by allowing 1 lb. for each square foot of grate area. About 3 lb. is the minimum quantity for boilers having a grate area less than 5 sq. ft. For instance, a boiler having a grate area of 10 sq. ft. requires 10 lb. of soda ash. In some cases this may be a trifle in excess of that actually required, but it is a fairly good average of what is necessary to obtain satisfactory results.

When soda ash is used care should be taken to see that all traces of this chemical are removed before the boiler is again put in operation. This can accurately be determined by testing the water occasionally with pink, *not* blue, litmus paper during the floating process. Litmus paper can be purchased from any drug store; the pink paper turns blue when immersed in water containing soda and retains its original color when the water is free from soda. The use of litmus paper is not feasible when natural feed water contains a high percentage of alkali. In such cases the skimming process should be continued from two to three hours, depending on the size of the boiler.

In cases where there is no water supply pressure it will be impractical to use the surface blow-off method. Under such circumstances the bottom blow-off process should be repeated many times.

On new installations it is advisable, wherever possible, to drain all condensation directly to the sewer during at least the first week of operation, thereby preventing passage of grease and dirt to the boiler from the system. The length of time during which this process should be continued depends somewhat on the amount of scale-forming material in the water, as it would be objectionable to accumulate excess scale on the heating surfaces due to the use of raw water.

PROTECTION OF BOILERS

The following physical precautions should be taken in all installations to prevent damage to the boiler:

1. There should be provided proper and convenient drainage connections for use if the boiler is not in operation during freezing weather.
2. Strains on the boiler due to movement of piping during expansion should be prevented by suitable anchoring of piping and by proper provision for pipe expansion and contraction.
3. Direct impingement of too intense local heat upon any part of the boiler surface, as with oil burners, should be avoided by protecting the surface with firebrick or other insulating material.
4. Condensation must flow back to the boiler as rapidly and uniformly as possible. Return connections should prevent the water from backing out of the boiler.
5. Low water cut-off devices which shut off the source of heat if the water in the boiler falls below a safe level are recommended for boilers fired with oil or gas.

SMOKE BREECHING AND CHIMNEY CONNECTIONS

Connections from the boiler outlet to the chimney should be air-tight and as short and direct as possible, preference being given to long radius and 45 deg., instead of 90 deg. bends. The bend at the entrance to the chimney should not project beyond the inside of the chimney and it should be pointed up from the inside of the chimney.

Where a battery of boilers is connected into a breeching each boiler should be provided with a tight damper. The breeching for a battery of boilers should not be reduced in size as it goes to the more remote boilers. Good connections made to a good chimney will usually result in a rapid response by the boilers to demands for heat.

PIPE CONNECTIONS TO BOILERS

The pipe connections which must be made to both steam boilers and hot-water heaters are:

1. Steam or flow connections from the top.
2. Return connections to the bottom.
3. Blow-off or drain connections.
4. Cold water connections for filling.

The *steam or flow connections* and also the *return connections* must be carefully designed to provide for expansion of the piping, as well as of proper size and number so as to give low outlet velocities, and uniform distribution of the return water over the boiler heating surfaces. The velocity of flow through the outlets of low pressure steam heating boilers should not exceed 15 ft. per second if entrainment of moisture is to be prevented, as with higher velocity the steam leaving the boiler may carry water with it.

Blow-off or drain connections should be made near the boiler and so arranged that the entire system may be drained of water by opening the drain cock. In the case of two or more boilers separate blow-off connections must be provided for each boiler on the boiler side of the stop valve on the main return connection.

Water service connections must be provided for both steam and water boilers, for refilling and for the addition of make up water to boilers. This connection is usually of galvanized iron pipe, and is made to the return main near the boiler or boilers. The heating contractor is required to run this line to the nearest water service main, in which the plumber has left a plugged tee.

For further data on pipe connections for steam and hot-water heating systems, see Chapters 20 and 21.

BOILER TROUBLES

A complaint regarding boiler operation generally will be found to be due to one of the following:

1. *The boiler fails to deliver enough heat.* The cause of this condition may be: (*a*) poor draft; (*b*) poor fuel; (*c*) inferior attention or firing; (*d*) boiler too small; (*e*) improper piping; (*f*) improper arrangement of sections; (*g*) heating surfaces may be covered with soot and (*h*) insufficient radiation installed.

2. *The water line is unsteady.* The cause of this condition may be: (*a*) grease and dirt in boiler; (*b*) water column connected to a very active section and, therefore, may not be showing actual water level in boiler, (*c*) boiler operating at excessive output.

3. *Water disappears from gage glass.* This may be caused by: (*a*) priming due to grease and dirt in boiler; (*b*) too great pressure difference between supply and return piping causing water to back into return; (*c*) valve closed in return line; (*d*) connection of bottom of water column into a very active section or thin waterway; (*e*) improper connections between boilers in battery permitting boiler with excess pressure to push water into boiler with lower pressure.

4. *Water is carried over into steam main.* This may be caused by: (*a*) grease and dirt in boiler; (*b*) insufficient steam dome or too small steam liberating area; (*c*) outlet connections of too small area; (*d*) excessive rate of output; (*e*) water level carried higher than specified.

5. *Boiler is slow in response to operation of dampers.* This may be due to: (*a*) poor draft due to air leaks into chimney or breeching; (*b*) inferior fuel; (*c*) inferior attention; (*d*) accumulation of clinker on grate; (*e*) boiler too small for the load.

6. *Boiler requires too frequent cleaning of flues.* This may be due to: (*a*) poor draft; (*b*) smoky combustion; (*c*) too low a rate of combustion; (*d*) too much excess air in firebox causing chilling of gases.

7. *Boiler smokes through fire door.* This may be due to: (*a*) defective draft in chimney or incorrect setting of dampers; (*b*) air leaks into boiler or breeching; (*c*) gas outlet from firebox plugged with fuel; (*d*) dirty or clogged flues; (*e*) improper reduction in breeching size.

If boiler trouble is attributed to oil and dirt in boiler one of the following tests will determine whether cleaning of boiler is necessary:

1. Draw off a small quantity of water from the try-cock near the water line. Boil this water in a pan and at the same time boil an equal quantity of water such as fed

to boiler in another pan (of same size if available). A marked difference in liberation of steam from the surface will indicate that the boiler should be cleaned.

2. After building a pressure in the boiler of 2 to 5 lb. open safety valve by means of a wire attached to lifting lever. Keep valve open for one minute. If water is discharged with the steam after the first rush of steam and water, it can safely be assumed that the boiler should be cleaned.

HOT WATER SUPPLY BOILERS

Boilers for hot water supply are classified as direct, if the water heated passes through the boiler, and as indirect, if the water heated does not come in contact with the water or steam in the boiler.

Direct heaters are built to operate at the pressures found in city supply mains and are tested at pressures from 200 to 300 lb. per square inch. The life of direct heaters depends almost entirely on the scale-making properties of the water supplied. If water temperatures are maintained below 140 deg. the life of the heater will be much longer than if higher temperatures are used, owing to decreased scale formation and minimized corrosion below 140 deg. Direct water heaters in some cases are designed to burn refuse and garbage.

Indirect heaters generally consist of steam boilers in connection with heat exchangers of coil or tube heaters which transmit the heat from the steam to the water. This type of installation costs more than a direct system, but has the following advantages:

1. The boiler operates at low pressure. Water hammer and cold water shocks are not transmitted to the boiler.
2. The boiler is protected from scale and corrosion.
3. The scale is formed in the heat exchanger in which the parts to which the scale is attached can be cleaned or replaced. The accumulation of scale does not effect efficiency although it will effect the capacity of the heat exchanger.
4. Water hammer due to formation of steam is minimized especially if the steam supply to the heater is under automatic control.
5. Discoloration of water may be prevented if the water supply comes in contact only with non-ferrous metal.

SELECTION OF HOT WATER SUPPLY BOILERS

The size of hot-water supply boiler selected is based upon the quantity of water used in 24 hours, the temperature rise, the peak load, the duration of peak load, and the size of storage tank used. A boiler capable of delivering per hour 1/24 of the 24-hour demand, operating continuously, would be sufficiently large, but it is good practice to provide at least 20 per cent reserve capacity in the boiler by selecting a boiler which can deliver per hour 1/20 of the 24-hour demand. The storage tank should be of such size that the water stored during off-peak hours, plus the hourly output of the heater will equal the demand during the period of peak load.

If the storage tank is already installed and is too small, a larger boiler must be used; the boiler having such capacity that the stored water plus the hourly heat output of the boiler equals the demand during the peak period.

Control of the water temperature by means of thermostats is discussed in Chapter 17 on Automatic Heat Control.

For the determination of hot water supply requirements, refer to Chapter 23 on Water Supply Piping for Buildings.

Hot water supply boilers usually are rated in gallons of water heated through a specified temperature rise within a given time. It is important to determine the temperature rise and the time required, as there is considerable variation in the values as used by different manufacturers.

CLEANING FLUES

All boilers are provided with flue clean-out openings through which the heating surface can be reached by means of brushes or scrapers. Flues of solid fuel boilers should be cleaned often to keep the surfaces free of soot or ash. Gas boiler flues and burners should be cleaned at least once a year. Oil burning boiler flues should be examined periodically to determine when cleaning is necessary.

CARE OF IDLE HEATING BOILERS

During summer months damage is frequently done to heating boilers and is often more serious than during the period of operation. This is due chiefly to corrosion following the combination of sulphur from the fuel with the moisture in the cellar air. At the end of the heating season the following precautions should be taken:

1. All heating surfaces should be cleaned thoroughly and if the boiler is of steel the heating surfaces should be given a coating of lubricating oil on the fire side.
2. All machined surfaces should be coated with oil or grease.
3. Connections to the chimney should be cleaned and in case of small boilers the pipe should be placed in a dry place after cleaning.
4. If there is much moisture in the boiler room, it is advisable to drain the boiler to prevent condensation of moisture on the surfaces when the boiler temperature becomes lower than the dew point. In steel boilers kerosene poured on the surface of the water will form a protecting film over the inside surface as the water is drained out.
5. When the boiler room is comparatively dry, in the case of cast iron boilers, the water level should be raised into the steam riser to exclude air from the boiler. A hot water system usually is left filled to the expansion tank.
6. The grates and ashpit should be cleaned.

CHAPTER 16

CONDUCTORS AND CONVECTORS FOR HEATING BY STEAM AND BY HOT WATER

THIS chapter is intended to apply to the salient data on the different kinds of heating elements pertaining to that field where heating is done by direct radiators, direct-indirect or concealed heaters (performing their function of emitting the necessary heat by radiation or conduction) or wherein the heating is done by concealed built-in heaters, cabinet heaters or indirect heaters, performing these same functions, mainly by the processes of convection.

It should be understood that any heater, whether it be a cast-iron *radiator* or one of the newer non-ferric, extended surface heaters specifically designed for enclosure within a wall or cabinet, heats the air which comes in contact with its surfaces almost wholly by conduction, the radiant effect being negligible.

Careless nomenclature has resulted in such confusion that the facts should briefly be reviewed.

An exposed cast-iron radiator emits from 10 per cent to almost 30 per cent of its heat emission, as radiant heat, as developed by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS Research Laboratory. The balance or major portion of its emission is, of course, by conduction to the air in contact with the heated surfaces. Thereupon the heated air, through convection, sets up a circulation which tends to distribute the heat more or less uniformly in accordance with the manner in which the convection currents are utilized.

When a cast-iron radiator, or one of the newer non-radiating heaters provided with extended conducting surfaces, is enclosed within a wall or cabinet, it emits practically no heat by radiation, functioning as a *conductor* rather than a *radiator*. Hence the term *radiator* or *radiation* applied to such heaters, or such heat-surface, is distinctly a misnomer, which should not be perpetuated. And it should be equally emphasized that air is heated by conduction in contact with a heated surface, while convection is that phenomenon by which heat is distributed within a fluid, liquid or gas.

In an effort to pioneer more descriptive nomenclature, borrowing the terms from no less an authority than Prof. L. P. Breckenridge, a direct heater shall be termed a *conductor* and an enclosed heater a *convector*.

The following is a glossary of the terms used:

1. *Conductor* or *radiator*—a heater exposed to view, and which transfers heat by radiation to objects which it can "see" and by conductance to the air currents which pass over it.

2. *Recessed conductor*—a heater set back into a wall recess but not enclosed in any way. A flat surface wall panel heater is a panel conductor.

3. *Convector*—a heater which is enclosed in a duct or cabinet and which gives off the heat to an air stream, which passes into the room which is to be heated.

4. *Cabinet convector*—a heater placed in an enclosure located within the room which is to be heated.

5. *Indirect convector*—a heater placed exterior to the room which is to be heated. There are both gravity indirect convectors and blast indirect convectors.

6. *Direct-indirect heater*, or conductor—convector—a heater arranged so that some of its sections operate as convectors, being partially housed in so as to heat air which enters from outside the room, while other sections and part of the housed sections may operate as conductors.

7. *Column conductor*—the cast-iron column type of *radiator* not manufactured since 1926.

8. *Tube conductor*—the cast-iron *radiator* of 1930.

9. *Wall conductor*—the wall type of cast-iron *radiator* of 1930.

The past few years have seen a greater variation and multiplicity of design in heaters for various purposes than has been experienced in any other branch of the heating industry. Until quite recently, practically all conductors for all purposes were made of cast-iron, of steel pipe, or of pressed sheet steel, and types were well standardized so that data on heat output could be given which were applicable to all makes. More recently the design of cast-iron conductors has changed, resulting in a greater heat output for a given weight, a more attractive product, and greater variation in the design and sizes of conductors on the market.

There are many new types of heaters for all types of service made of non-ferrous metals, which lend themselves to construction of much lighter and smaller units for a given heat output. Cast-iron heaters are still used predominently as conductors, but non-ferrous convectors are rapidly replacing cast-iron convectors for cabinet, concealed, and blast heating. Extended surface, as contrasted with direct surface, is a characteristic feature of most of the new designs of non-ferrous metal convectors.

UNIT OF HEAT OUTPUT

In the past the unit of measure recognized in computing heat emission of radiators was the square foot of heating surface. The use of this unit is being discarded rapidly, however, for the reason that heat emission depends upon the design of the heater as well as upon its surface area. The engineer is interested primarily in the amount of heat emitted by, rather than the amount of surface in a heat-transferring agent. As a result heaters are now rated on the heat given off either in B.t.u. per hour or in equivalent square feet, based on 240 B.t.u. per hour, and there is a growing demand for some sort of new measure which will express also the room-comfort effect of the heater.

The purpose of supplying heat to a room is not alone to increase the temperature of the building, but also the purpose often is to maintain a condition of comfort for the occupants. In this connection it cannot be denied that comfort-feeling for human beings in winter calls for the delivery of warmth to the lower part of the room or to the zone of occupancy, instead of for overheating the parts near the ceiling. Recognition of this principle has led to considerable study and speculation on economical application or distribution of heat in domestic heating.

One scheme for securing maximum comfort in the zone of occupancy with minimum heat loss is the use of heaters especially designed to give off the greater part of their heat by radiation directly to the occupants in the lower or occupied portion of the room, without unduly heating the upper part of the room.

Another method of accomplishing the same result is in the proper use and application of concealed and cabinet heaters, whereby the heat is transferred to the room by means of heated air continuously projected horizontally slightly above the plane of occupancy of the room and replaced by an equal volume of cooler air drawn into the base of the cabinet convector from the floor, thus creating a local circulation within the zone of occupancy and tending to prevent overheating of the air in the upper part of the room.

FACTORS AFFECTING THE HEAT EMISSION

The heat emission from a heater is affected by a number of conditions. These include the temperature and the moisture in the air of the room, the temperature of the steam or hot water in the heater, the speed of circulation of the air over the heater, the kind of paint used on the heater, the location of the heater in the room, and whether or not it is in an enclosure.

Temperature

The heat emission depends upon the difference in temperature between the heating medium in the conductor or convector, and the temperature of the surrounding air. The exact relationship depends upon the design of the heater and the relative proportion of conducted and convected heat. However, the Code of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS for Testing Radiators, assumes the following relationship as applicable to the average run of direct cast-iron conductors.

$$H = K\,(T_s - T_r)^{1.3}$$

where

H = the rate of heat emission in B.t.u. per hour per square foot of surface.
K = a constant.
T_s = the temperature of heater assumed to be the temperature of the steam or hot water.
T_r = the temperature of the room in which the heater is located.

The Society's Code also accepts 215 deg. and 70 deg., respectively, as standard steam and room temperatures. Accepting this assumption, the heat emission for any other than standard conditions is equal to:

$$H_x = H_s\,\frac{(215 - 70)^{1.3}}{T_s - T_r}$$

where

H_s = the heat emission under standard conditions.

If the conductor or convector is to be used under any other than standard conditions of room and steam temperature, this fact should be given consideration. This may be done by applying the foregoing formula to the standard heat output of the heater or more conveniently by mul-

TABLE 1. HEAT EMITTED BY DIRECT CAST IRON HEATERS—CONVERSION FACTORS

STEAM PRESSURE		TEMP. OF STEAM IN DEG. FAHR.	TEMPERATURE OF ROOM					
Vacuum In. Hg.	Lb. Absolute		80 deg. fahr.	75 deg. fahr.	70 deg. fahr.	65 deg. fahr.	60 deg. fahr.	50 deg. fahr.
23.4	3.71	150	0.388	0.424	0.462	0.499	0.538	0.617
19.7	4.75	160	0.462	0.499	0.538	0.577	0.617	0.697
15.3	5.99	170	0.538	0.577	0.617	0.657	0.697	0.782
12.3	7.51	180	0.617	0.657	0.697	0.740	0.782	0.868
8.7	9.33	190	0.697	0.740	0.782	0.825	0.868	0.955
6.5	11.52	200	0.782	0.825	0.868	0.911	0.955	1.045
LB. GAGE								
1	15.7	215	0.911	0.955	1.000	1.045	1.091	1.183
2	16.8	219	0.947	0.991	1.036	1.081	1.128	1.220
3	17.8	222	0.973	1.018	1.063	1.109	1.155	1.249
4	18.9	225	1.000	1.045	1.091	1.137	1.183	1.277
5	19.6	227	1.018	1.063	1.109	1.155	1.202	1.296
6	20.8	230	1.045	1.091	1.137	1.183	1.230	1.325
8	22.8	235	1.091	1.137	1.183	1.230	1.277	1.373
10	24.9	240	1.137	1.183	1.230	1.277	1.325	1.421

These conversion factors multiplied by the heat emitted by a conductor operating at 215 deg. fahr. in a room at 70 deg. fahr., give the heat emitted by a conductor operating under the indicated conditions.

tiplying its standard heat emission by the proper factor taken from Table 1. In estimating the size of heater required for a room under other than standard conditions divide the estimated heat loss from the room by the factor for the prevailing conditions as given in Table 1, and choose a heater which will supply this corrected heat loss when operating under standard conditions. Thus, if a room whose heat loss with 60 deg. air is 7,200 B.t.u. per hour, is to be heated to 60 deg. with steam at 200 deg., divide 7,200 by 0.955 giving 7,539, and pick a heater which will give 7,539 B.t.u. per hour when supplied with 215 deg. steam in a 70 deg. room.

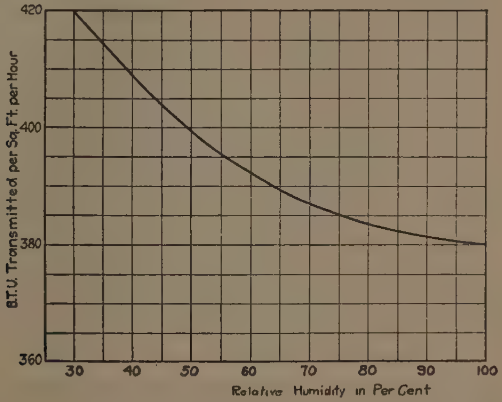


FIG. 1. EFFECT OF HUMIDITY ON HEAT TRANSMISSION

Effect of Humidity

Fig. 1 shows the effect of increasing the humidity upon the heat transmission. It will be noted that with extreme change of humidity there is a slight change in the heat transmission.

Heating the Conductor

It is often very important to know the maximum condensation that occurs in a heater when steam is turned on. Fig. 2 shows the condensation rate in pounds per hour for the time elapsing after steam is turned into a column conductor. In practice the rate of steam supply to the conductor while heating up is, however, frequently retarded by controlled elimination of air through air valves or traps, and if sufficient time is allowed for the heating-up process, overload on the boiler may practically be eliminated.

Effect of Paint

Painting a conductor changes the emissivity constant of the radiating surface, but has practically no effect upon the heat lost by convection. It is, therefore, a surface effect and it makes no appreciable difference what paints are placed on the heater as a priming coat; the results are always dependent upon the last coat of paint. In conductors having a large proportion of radiating surface such as pipe coils or wall coils, the effect of painting will be more marked than in tubular conductors having a comparatively small radiating surface in proportion to the amount of convecting surface. Most finely ground pigments have about the same radiation constant as black cast-iron. Therefore paints having finely ground pigments will usually have little effect. Bright metals have a much lower radiation constant and therefore, bronze metallic paints will reduce the direct radiation emission from a conductor.

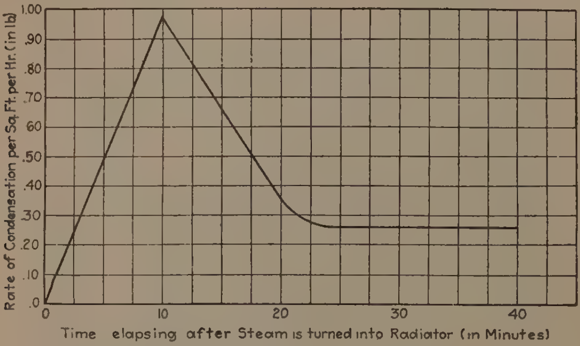


FIG. 2. CHART SHOWS THE STEAM DEMAND RATE FOR HEATING-UP A CAST-IRON CONDUCTOR WITH FREE AIR VENTING AND AMPLE STEAM SUPPLY

The effects of painting a six-section 32-in. three-column conductor as found by Wm. H. Severns are given in Table 2.

Effect of Enclosures

It is assumed generally that an enclosed conductor shows a decreased heat emission. This is borne out by results obtained by Kratz and Fahnestock[1], Table 3. These data indicate that the heat emission from the enclosed heater, equals or exceeds that of an exposed heater only in

TABLE 2. EFFECT OF PAINTING 32-IN. THREE COLUMN, SIX-SECTION CAST IRON COLUMN CONDUCTOR

RADIATOR No.	FINISH	AREA SQ. FT.	COEFFICIENT OF HEAT TRANS. B.T.U.	RELATIVE HEATING VALUE PER CENT
1	Bare iron, foundry finish	27	1.77	100.5
2	One coat of aluminum bronze	27	1.60	90.8
3	Gray paint dipped	27	1.78	101.1
4	One coat dull black Pecora paint	27	1.76	100.0

---

[1] Effect of Enclosures on Radiator Performance, by A. P. Kratz and M. K. Fahnestock, JOURNAL, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, June, 1927.

the case where the enclosure is much higher than the heater, so as to produce a pronounced chimney effect. There is evidence, however, that under some conditions of installation the enclosure may so improve the distribution of heat to the occupied zone that the decreased heat output will produce a satisfactory comfort condition.

Figs. 3, 4 and 5 give results of a study of the relative heating effect of bare and enclosed radiators as made at the University of Illinois.[2]

Fig. 3 gives the relative heating effect of a bare radiator and the same radiator in a well designed enclosure. The enclosed radiator condensed 13 per cent less steam than the bare radiator and maintained the same breathing line temperature. Below the breathing line the enclosed radiator gave a higher temperature, while the bare radiator gave a higher temperature at the ceiling.

Fig. 4 shows the relative heating effect of a bare radiator and the same radiator in two poorly designed enclosures. The enclosure decreased the rate of condensation slightly, but did not satisfactorily heat the room.

Fig. 5 shows the relative heating effect of a bare radiator and the same radiator with a well designed shield. The shield had the effect of decreasing the condensation by 11 per cent, and gave the same breathing line temperature with a slightly higher temperature below the breathing line and a lower temperature at the ceiling.

These results show that properly designed enclosures and shields will result in greater efficiency and consequently more economical heating. However, this improved effect is not had except where the enclosure is properly designed.

To accomplish the best results, care must be exercised to follow certain rules in designing the enclosure, the most important of which are:

1. Enclosures should be insulated with 1 in. magnesia or asbestos block, lined with bright tin or non-corrosive sheet metal, placed next to the conductor.
2. The surface of the conductor should be painted flat black, maroon japan, white enamel or white zinc. If the conductor is entirely concealed it may be unpainted.
3. The free area of the grille or opening at the outlet should be not less than the free area through the sections of the conductor.
4. The free area of the grille or opening at the inlet should be not less than 80 per cent of the free area at the outlet.
5. If the outlet is in the face of the enclosure so that the air flow is horizontal, the free area of the outlet should be at least 150 per cent of the free area about the conductor, and the clear height between the top of the conductor and the underside of the top of the enclosure should be not less than the depth of the enclosure.
6. Best results are obtained with a tight fitting enclosure, provided the free area about the conductor at point of greatest restriction is not excessive. As a general rule the efficiency of the conductor is inversely proportional to the depth of the enclosure.

TYPES OF HEATERS

Types, sizes, and heat emission for tube conductors and for the various other forms of cabinet convectors and for the extended surface-blast convectors now on the market, are not sufficiently well standardized to give heat-emission tables applicable to all makes of a given type. For

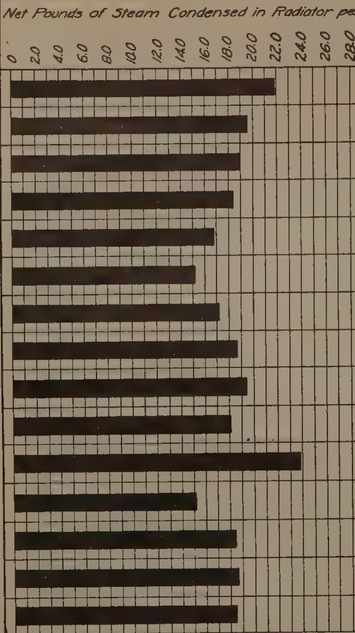
---

[2] Investigation of Heating Rooms with Direct Steam Radiators Equipped with Enclosures and Shields, by A. C. Willard, A. P. Kratz, M. K. Fahnestock and S. Konzo, JOURNAL OF AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Vol. 35, No. 4, April, 1929.

TABLE 3. EFFECT OF ENCLOSURE ON HEAT EMISSION FROM RADIATOR

Enclosure Number	Description of Enclosure			Free Area of Inlet sq. in.	Free Area of Outlet sq. in.	Net Pounds of Steam Condensed in Radiator per Hour	Relative Condensing Capacity Percent	Enclosure Number
	Height of Top of Enclosure Above Top of Radiator	Inlet	Outlet					
	Radiator not enclosed—Painted (not dipped) with two coats of black Pecora paint					21.93	100.0	
1	0.0"	4"×50" Across front	9¼"×50" Open top	200.0	462.5	19.53	89.1	1
2	0.0"	4"×50" Across front	9¼"×50" Grilled top	200.0	209.4	18.98	86.5	2
3	0.0"	4"×50" Across front	12½"×50" Open front	200.0	625.0	18.31	83.5	3
4	0.0"	4"×50" Across front	4"×50" Open front	200.0	200.0	16.89	77.0	4
5	0.0"	4"×50" Across front	4"×50" Grilled front	200.0	92.1	15.17	69.2	5
6	17½"	4"×50" Across front	4"×50" Grilled front	200.0	92.1	17.16	78.3	6
7	34"	4"×50" Across front	4"×50" Grilled front	200.0	92.1	18.77	85.6	7
8	0.0"	4"×82½" Across front and ends	9¼"×50" Grilled top	330.0	209.4	19.43	88.6	8
9	0.0"	2"×82½" Across front and ends	9¼"×50" Grilled top	165.0	209.4	18.09	82.5	9
10	34"	4"×82½" Across front and ends	9¼"×50" Open top	330.0	462.5	23.92	109.1	10
11	0.0"	4"×82½" Across front and ends	4"×50" Grilled front	330.0	92.1	15.17	69.2	11
12	0.0"	Punched metal grille front and ends, solid top. Grillework beginning 4" above floor. F.A. of grille = 44%				18.47	84.2	12
13	0.0"	Woven metal grille front and ends, solid top. Grillework beginning 4" above floor. F.A. of grille = 53%				18.74	85.5	13
14	0.0"	Same as (13) with F.A. of Grille = 42%				18.47	84.2	14

Note: 20 Section, 38"-3 Column, (direct) C.I. Water Type Radiator used in all tests.



Note: Steam Temperature constant at 216°F. Breathing Line Temperature = 80°F.

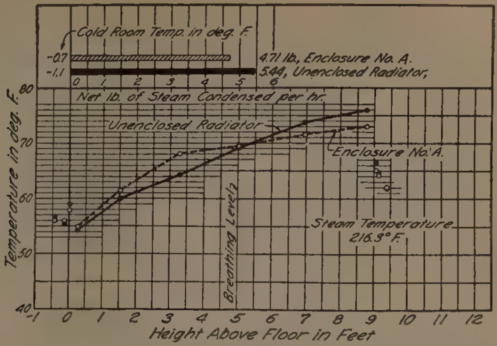


Fig. 3. Room Temperature Gradient and Steam Condensing Rate for Radiator with Well Designed Enclosure

such information the reader is directed to manufacturers' guarantee in the catalog data section of The Guide and elsewhere.

Pipe Coil Convectors

Table 4 has been developed by a method of deduction from the available data on such experimental work on pipe coils as has been recorded, and does not represent definite experimental results of tests.

Cast-Iron Gravity Indirect Convectors

Table 5 gives the cubic feet of air per hour (measured at 70 deg. fahr.) usually allowed per square foot of heating surface, through cast-iron gravity indirect convectors.

Table 6 gives the final temperature of the air leaving cast-iron gravity indirect convectors corresponding to different entering temperatures and different cubic feet of air per hour per square foot of surface.

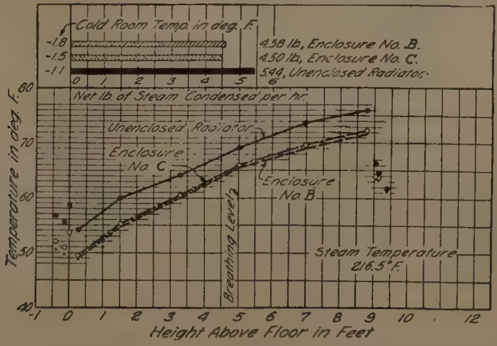


Fig. 4. Room Temperature Gradients and Steam Condensing Rates for Radiator with Improperly Designed Enclosures

TABLE 4. HEAT EMISSION OF DIRECT PIPE COIL CONDUCTOR FOR STEAM

Steam Temperature 215 deg. fahr. Room Temperature 70 deg. fahr.

WALL COILS—COILS PLACED VERTICAL—PIPES HORIZONTAL

B.t.u. per Lineal Feet of Coil per Hour (Not Lineal Feet of Pipe)

SIZE OF PIPE COIL CONDUCTOR	1″	1¼″	1½″
Single Row	132	155	185
Two	252	312	348
Four	440	545	616
Six	567	702	793
Eight	651	796	907
Ten	732	907	1020
Twelve	812	1005	1135

WALL COILS—COILS PLACED VERTICAL—PIPES VERTICAL

Emission varies in inverse ratio of the height of the coil

Use 100 B.t.u. per lineal feet of pipe as an average for 1¼ in. coil, 10 ft. high.

CEILING COILS—COILS PLACED HORIZONTALLY—PIPES HORIZONTAL

Emission is equal to that of a single row coil

Allowance must be made, however, if the coil is at the ceiling in a higher temperature. In this case use:

126 B.t.u. per lineal feet of pipe for 1 in. coils.
146 B.t.u. per lineal feet of pipe for 1¼ in. coils.
175 B.t.u. per lineal feet of pipe for 1½ in. coils.

TABLE 5. CUBIC FEET OF AIR PER HOUR PER SQUARE FOOT OF HEATING SURFACE FOR CAST IRON GRAVITY INDIRECT CONVECTORS

Indirect heaters supplying 1st floor registers	150 cu. ft. per hour
Indirect heaters supplying registers 7 ft. above first floor	200 cu. ft. per hour
Indirect heaters supplying 2nd floor registers	300 cu. ft. per hour
Indirect heaters supplying 3rd floor registers	350 cu. ft. per hour

TABLE 6. FINAL TEMPERATURE OF AIR LEAVING ¾ IN. PIN, CAST-IRON, GRAVITY INDIRECT CONVECTORS

TEMPERATURE ENTERING AIR DEG. FAHR.	CUBIC FEET OF AIR (AT 70 DEG.) PER HOUR PER SQUARE FOOT RADIATION												
	50	75	100	125	150	175	200	225	250	275	300	325	350
−10	132	130	128	126	123	121	119	116	113	111	108	105	103
0	136	134	132	130	127	125	123	120	117	115	112	109	107
10	140	138	136	134	131	129	127	124	121	119	116	113	111
20	144	142	140	138	135	133	131	128	125	123	120	117	115
30	148	146	144	142	139	137	135	132	129	127	124	121	119
40	152	150	148	146	143	141	139	136	133	131	128	125	123
50	156	154	152	150	147	145	143	140	137	135	132	129	127
60	160	158	156	154	151	149	147	144	141	139	136	133	131
1st Floor	→	→	→	→	→	→	→						
2nd Floor	→	→	→	→	→	→	→	→	→	→	→		
3rd Floor	→	→	→	→	→	→	→	→	→	→	→	→	→

Note.—Temperature of air entering room shall be assumed lower than temperature of air leaving convector as follows: 1st Floor, 5 deg. lower; 2nd Floor, 8 deg. lower; 3rd Floor, 10 deg. lower.

Table 7 illustrates the difficulty in tabulating any definite conductor outputs, since there is so much variation between the product of the different manufacturers. Only on the four-tube and six-tube sizes is there practical agreement in output value.

Pin-Type Conductors

Table 6 is for ¾ in. pin-type convector using steam at 1 lb. pressure. For 1 in. pin-type the temperature rise of the air is about 95 per cent of the corresponding rise for ¾ in. pin-type, and for hot water at 170 deg. fahr. the temperature rise of the air ranges from 80 to 85 per cent of the corresponding temperature rises, with steam at 1 lb. pressure.

LOCATION OF HEATERS

It should be made a rule to install heaters beneath or near the space of greatest heat loss. The best place is underneath an outside window.

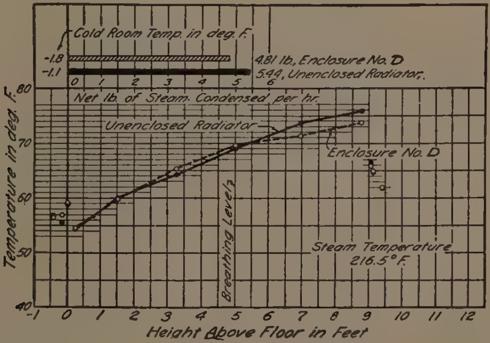


Fig. 5. Room Temperature Gradient and Steam Condensing Rate for Radiator with Shield

This seems logical for the following reasons:

1. Heat emitted by radiation from the heater will counteract the effect of heat radiated out through the window from occupants in the room.

2. Cold air leaking in through the window is warmed before it reaches the interior of the room.

3. Air currents from the heaters pass upward, mingling with the cold infiltering air, and form a screen of warm air protecting against cold window drafts.

4. There is less discoloration of walls from dust arising from the heater. If the heater cannot be placed underneath the window, then it should be located as near the window as possible, near outside doors, underneath skylights, near to very exposed walls or corners, etc.

SELECTION OF HEATERS

In selecting the proper heater for heating a given room or space, the following procedure should be followed:

1. Estimate the total loss from the room or space to be heated in accordance with Chapter 2, making proper allowance for exposure, wind velocity, height of ceiling, etc.

TABLE 7. VARIATION IN DIMENSIONS AND CATALOG RATING OF 10-SECTION TUBULAR CONDUCTORS MADE BY SIX MANUFACTURERS

No. of Tubes	3	4	5	6	7
Width of Conductor—Inches	4.6–5.1	6.0–7.0	8.0–8.9	9.1–10.4	11.4–12.8
Length per Section—Inches	2.5	2.5	2.5	2.5	2.5–3.0
HEIGHT WITH LEGS—INCHES	HEAT EMISSION—SQUARE FEET				
13–14	....	....	....	20	25.0–32.5
16–18	....	....	28.5	....	30.0–38.3
20–21	15.0–17.5	20.0–22.5	25.0–31.2	30	36.7–45.0
22–23	20.0–21.3	25	30.0–33.9	35	40.0–45.2
25–26	20.0–26.7	25.0–27.5	32.5–39.8	37.5–40.0	50.0–53.5
30–32	25.0–30.9	33.3–35.0	40.0–48.6	50	63.3–62.5
36–38	30.0–36.7	40.0–42.5	50.0–56.5	60	70.0–75.4

Direct Radiation

2-*A*. Decide upon the type and the number of heaters to be used. Then find from manufacturers guaranteed performance tables for the particular type of heater as given in the catalog section of THE GUIDE or elsewhere, the number of sections or the size of each heater required to supply the heat loss from the room.

Cabinet or Concealed Convectors

2-*B*. If convectors for which heat emission data are given only for use as conductors are to be used, estimate the percentage decrease in heat emission from a conductor thus installed and add this percentage to the heat loss from the room as estimated in (1).

3-*B*. From the manufacturers guaranteed performance data as given in the catalog section of THE GUIDE or elsewhere, find the number of sections or size of each convector to supply the corrected heat loss found in 2-*B*.

Indirect Gravity Convectors

2-*C*. Add to the estimated heat loss from the room from (1) any additional heat loss, not entering the room to be heated, from the duct or enclosure of the convector. If the enclosure or ducts are so designed as to decrease the heat emission of the convector as given by the manufacturer, estimate this percentage decrease and add it also to the estimated heat loss from the room as given in (1).

3-*C*. From the manufacturers' guaranteed data as given in the catalog section of THE GUIDE or elsewhere, find the number of sections or size of convector to supply the estimated heat loss given by 2-*C*.

Blast Convectors

2-*D*. Decide upon the desired temperature of warm air entering the room and from this temperature and the estimated heat loss from the room from (1), calculate the quantity of air to be supplied.

3-*D*. Increase the temperature of the air entering the room by an amount sufficient to take care of the heat loss from the duct system to give the temperature of air leaving the blast convectors.

4-*D*. Estimate the temperature at which the air will enter the cold side of the blast convectors, and calculate the temperature rise through the convectors.

5-*D*. From the manufacturers' guaranteed performance data as given in the catalog section of THE GUIDE or elsewhere, find the required number of sections or size and arrangement of the blast convectors to give the temperature rise indicated by 4-*D*, to the air volume given in 2-*D*.

6-*D*. The resistance offered by the convector chosen, must be added to the resistance of the duct system in choosing the fan. In order not to make this resulting resistance too high, consideration should be given to the resistance of the convector in selecting it.

CHAPTER 17

AUTOMATIC HEAT CONTROL

Types of Thermostats; Temperature Control Requirements; Residence Heating; School and Church Heating; Office Heating; Factory Heating; Greenhouse Heating; Swimming Pool Heating; Domestic Hot Water Heating; Manufacturing Processes; Household Devices.

THE control of heat as applied to the multitudinous industries and processes where heat is employed involves much more than the mere regulation of temperatures. Heat control usually means some arrangement that will not permit overheating, and this arrangement or device may be manual, semi-automatic or full automatic.

Whether the heat supply be for human comfort, for process work, or for any of the other myriad requirements, it should be equal to the maximum demand, and any quantity wanted short of this maximum demand must be subject to control. It is obvious that the control of heat is necessary not only to comfort, perfection of product, etc., but also that it is necessary if economy shall be achieved.

Heat control may be divided into the following classes:

1. Control of heat employed to give bodily comfort.
2. Control of heat in process work in manufacturing industries.
3. Control of heat in laboratory research. This is of the greatest importance in all matters pertaining to the exactness of the heat components.
4. Control of heat in service-rendering devices such as refrigerators, laundries, household appliances, etc.

The subject matter of this division will deal largely with the control of heat as employed in the daily activities of life and to a great extent it will confine itself to automatic heat control, since the refinements in the art of heating find its highest expression in automatic control.

The term *heating* will include everything pertaining to air temperatures in the spaces controlled. Where water temperatures or metal temperatures are involved appropriate words will be added.

For convenience in classification *heating* is divided as follows:

1. Residence Heating.
2. School and Church Heating.
3. Office Heating.
4. Factory Heating.
5. Theater Heating.
6. Greenhouse Heating.
7. Swimming Pool Heating.
8. Domestic Hot Water Heating.
9. Bath and Shower Heating.

THERMOSTATS

Primarily there are four types of thermostats used today in the heating industry. (See Figs. 1, 2, 3 and 4).

The *first* type may be called the diaphragm type which, by means of an expanding liquid or gas within a diaphragm or bellows, furnishes motion; and this motion may be mechanically transmitted in proportion to the rise and fall of temperatures surrounding the diaphragm.

The *second* type may be called the bi-metal type which furnishes motion by means of intimately attached metals having dis-similar coefficients of expansion. This type is inherently more sensitive to temperature changes than the first type but lacks in force to transmit or cause motion.

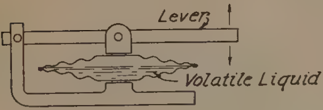


Fig. 1. Diaphragm Type Thermostat

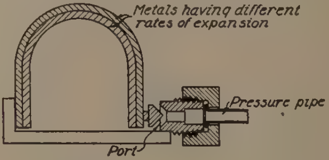


Fig. 2. Bimetallic Type Thermostat

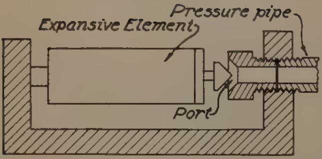


Fig. 3. Direct Expansion Type Thermostat

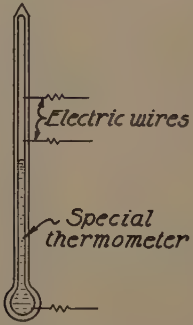


Fig. 4. Mercury Type Thermostat

Four General Types of Thermostats

The *third* type operates by direct expansion and contraction of a substance which has a high coefficient of expansion such as hard rubber. The slight movement of the thermostatic element usually must be multiplied through a system of levers.

The *fourth* type is the mercury type. Usually it takes the form of a standard thermometer with electric contacts carried through the glass tube at the degree points where motion is to take place. For instance, if heat is to be turned on at 68 deg. and off at 70 deg., the contacts would be welded through the glass tube at 68 deg. and 70 deg. This is a very sensitive type of thermostat, but is not subject to adjustment for different temperatures. This type of thermostat is well-adapted for situations where there is considerable vibration, as for instance in the control on moving vehicles.

Thermostats may further be subdivided into two classes or types.

One, the self-contained or unit type, which by means of its thermo-element exerts its resultant force directly upon the flow of the medium through the agency of a damper or valve.

Two, the pilot type, which in itself transmits only sufficient motion to operate very small valves or to make and break light electrical contacts. Through these small valves liquids or gases already under pressure may be employed to an unlimited degree. So, also, the delicate electrical contacts may energize relay circuits which in turn may place in operation the most gigantic machinery.

A further classification may be made, namely, thermostats having two or more thermo-elements acting in conjunction to transmit a combined or integrated motion.

Thermostats are designed with a multitude of motion-ratios and modifications to meet a wide range of requirements, a few of which are:

1. Room thermostats for controlling *air temperatures* in living quarters.
2. Immersion thermostats for controlling *liquid temperatures* in tanks.
3. Thermostats for controlling or limiting *flue gas temperatures*.
4. Thermostats for controlling *maximum and minimum pressure or temperature* conditions in boilers, refrigerators, etc.
5. Thermostats for operating electric circuits and for closing fuel valves on automatic fuel burners on failure of any part of apparatus or of fuel, commonly called *safety thermostats*.

The ever-increasing demand for greater perfection in heating, with minimum attention and care, are responsible for the many thermostatic devices which not only control but limit or stop automatic fuel feeding-machines when safety demands it.

RESIDENCE HEATING

Homes of every description and in nearly every clime from cottages to palaces require some heat at some time beyond that given by the sun in its daily course.

This heat may be called manufactured heat, and in order that it shall be supplied in the correct amount to produce comfort some means of regulation must be used, it being assumed that the equipment employed to deliver the heat is of sufficient capacity to produce enough under any and all circumstances. In modern accepted practice heating equipment may today be called upon to supply the maximum load, and tomorrow 90 per cent of it may be or should be idle if the human comfort curve and heat curve run at all parallel.

An average residence, not employing mechanical ventilation but maintaining a temperature of approximately 70 deg., can, in a climate having an average temperature of 40 deg. during the heating season, closes off its heat source fully one-third of the time; that is, for a heating season of 5,040 hours the heat supply may well be cut off for more than 1,700 hours.

Refinements, such as conditioning of air, effect the heat requirements, but also need additional control to perfect their operation.

The first requisite in any well-ordered heating system is a design which will give most nearly 100 per cent perfect heat. The second requisite, only slightly less in importance, is economy of operation.

Residence Heating Control

Automatic control of heat in residences is invariably accomplished by means of thermostats, and these devices are located in representative or key places; never, of course, on an outside wall or near a window, nor too close to radiators or in a drafty hallway. They should be located on a wall of the room which has the greatest number of hours of occupation, preferably the living room.

Fig. 5 illustrates a hot water heating system with thermostatic control. Thermostat No. 1 asks for heat and gets it unless thermostat No. 2 claiming the heating medium is already too hot, prevents it. Thermostat No. 3 will shut down everything regardless of No. 1 and No. 2, if once having been warm it gets cold, indicating that the pilot flame is out; or if following operation of the burner it does not get warm promptly, indicating that ignition has failed.

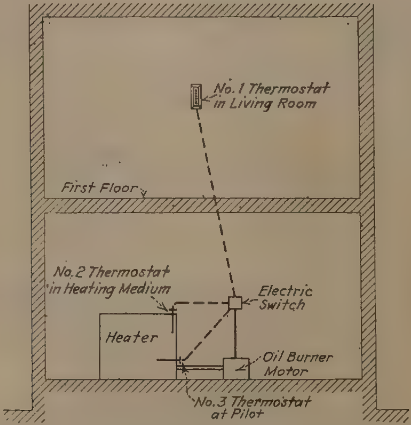

No. 1 Thermostat in Living Room
First Floor
No. 2 Thermostat in Heating Medium
Electric Switch
Heater
Oil Burner Motor
No. 3 Thermostat at Pilot

Fig. 5. Typical Arrangement of Hot Water System with Thermostatic Control

Fig. 6 illustrates a steam or vapor plant performing the dual service. Either the room thermostat or the tank thermostat may cause the opening of the valves in the mains which supply them and will start the fuel burner, but the burner will not stop unless both thermostats have closed their valves, or unless the steam pressure shall have reached that allowed by the pressurestat. This applies to an oil burner, gas burner or coal stoker. Safety controls, though not shown, should be used.

In the average residence one thermostat is usually sufficient, but as the home enlarges the desirability for added control-points, which means added refinements, increases.

The modern automatic fuel burner has made possible a marked advance in automatic heat control over the older *banked fire* furnaces and many practical combinations of automatic heat control now are available for use with oil, coal and gas burners, as well as with electric heating.

One fuel burner may do a double service or triple service, that is, it may heat the residence, the hot water for domestic service and the lodge or garage that may be located some distance from the residence. Interconnection of thermostats on the several services may be made so that the fuel burner will stop on *no demand* and start on *first demand* for heat.

For convenience and for complete freedom of attention by the resident, central station or district heat, purchased on a meter basis, just as electricity or water is bought, may be the most nearly ideal method of heating, and since readiness for maximum service is practically a constant throughout the entire heating season, automatic control with district heating is not only desirable but is highly productive from a cost standpoint.

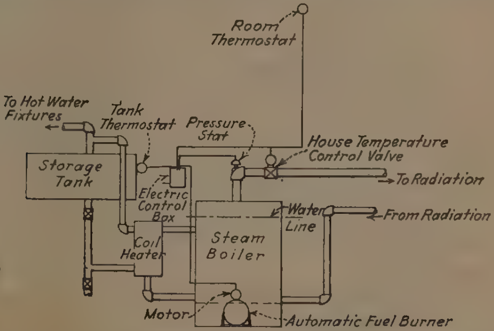


FIG. 6. TYPICAL ARRANGEMENT OF STEAM OR VAPOR SYSTEM WITH TWO THERMOSTATS CONTROLLING AUTOMATIC FUEL BURNER USED FOR HOUSE HEATING AND WATER HEATING

The tendency toward greater refinement in residence heating is sure to bring air conditioning more and more into use, and to meet this demand automatic control, that is, the thermostat, stands ready to do its share.

SCHOOL AND CHURCH HEATING

To make school houses and churches comfortable, under all conditions of occupancy, automatic control of temperatures and also of air volumes and in many instances the control of the condition of the air is necessary. Buildings occupied intermittently such as schools, require a heating system having considerable flexibility. Steam or vapor, hot water and warm air all may be used with success.

Where the air is to be taken in large volumes direct from the outside without regard to temperatures, steam usually is preferred to hot water as a heating medium. The heating surface both in tempering coils and direct radiators is materially less for steam and there is less possibility of freezing. Thermostatic control is employed on the direct radiation and on the indirect radiation or convectors used for heating the air. On systems requiring mechanical ventilation, the air temperature may be controlled by means of thermostats with dampers in the air ducts.

The heater shown in Fig. 7 usually serves several classrooms. The thermostat causes the double-mixing damper to vary the mixture of warm air from the heater and tempered air from the by-pass air way so as to maintain optimum conditions in the room. The thermostat also causes the diaphragm valve on the radiator to close when the room becomes too warm. The cumulative damper in the by-pass air way is remotely operated by hand. When it is closed all the air and all the heating power of the re-heaters goes to the coldest or slowest-to-heat room automatically. The zoning damper also is manually controlled. When the leeward zoning dampers are closed a heavy interior air pressure can be delivered against cold winds.

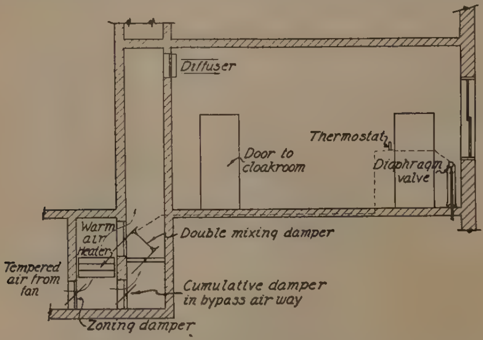


Fig. 7. Arrangement of Automatic Control for a Classroom

Many states and cities have enacted rules and regulations governing installations where public health and comfort are involved.

While automatic fuel burners are well-adapted to the intermittent service required in schools and churches and respond admirably to the several thermostatic controls, care should be exercised in the location of burners, as well as the mechanical blowers, often used with them on account of the noise which may accompany operation of machinery. (See Chapter 12, Heating by Oil).

OFFICE HEATING

The highest mental alertness is necessary to secure business efficiency and in this equation heat is a very important factor. Too much heat is quite as destructive to efficiency as not enough heat, so that it is incumbent upon some sort of automatic heat control to furnish comfort. Office buildings as a class consume more heat in proportion to the floor space than other types of buildings, and when compared with the productive floor areas the heat consumption in such buildings shows a decided waste unless controlled very efficiently.

It is not usually necessary to maintain the office-hour temperature during the hours of non-occupancy. It should not be necessary to overheat a large space just because some small part of that space requires extra warm conditions. Still another factor is that excess temperatures are likely to follow the sun, and that the leeward side is overheated before the windward side gets comfortable. To meet all these requirements in an acceptable manner and at the same time to give due regard to efficiency and economy of operation of the complete heat installation, automatic heat control is required.

Hot water is an ideal heating medium for office buildings, since the temperatures in the radiators can be controlled at the source within practical limits if the requirements within the building are identical throughout or are met by exactly proportioned heating surfaces.

To meet the different temperature requirements in different parts or sections of a building, the piping can be zoned and the flow of water automatically restricted to the sections requiring a lower temperature, and possibly arrested entirely during many hours. The periods of non-occupancy can be satisfied very acceptably by lowering the temperatures of the circulating water. (It is not recommended that the flow of heat be reduced by retarding the general water circulation).

While it appears that the major requirements would be met with this method of heating, at least from the standpoint of automatic and efficient control, very few office buildings are today heated by forced circulation hot water. Steam, circulated at close to atmospheric pressure, is used almost universally.

Several methods of steam heating in large office buildings are in use, all of which employ automatic heat control to a greater or lesser degree.

One method is that of maintaining temperatures in the radiators which will balance as nearly as possible the heat given off by the radiation against that required by the losses from the structure. These temperatures are controlled by varying the pressure or vacuum within the radiator. The higher the vacuum the lower will be the temperature, and thus the temperature in the radiator will be reduced. This method is sometimes supplemented with thermostatically operated valves in rooms or spaces where overheating is likely to occur, or where the same temperatures are not desired in all the rooms or spaces of the building.

Another method employs automatic control on the steam supply to the system as a whole, but with fixed restrictions in the openings to radiators or groups of radiators. The component of the outside elements—temperature, wind, sun—is utilized to anticipate the inside heat requirements by means of a thermo-element placed outside of the building. The steam may be supplied at pressures below atmosphere or above atmosphere as requirements demand.

Another method embodies the use of a system of thermostatically operated valves. The building is first divided into sections or zones which may have quite different heat requirements. With this method of control;

First: The zoning should be done with reference to the compass, since the north and west quarters in most localities require considerably more heat during the heating season than do the south and east quarters.

Second: The period of occupancy should be taken into account, since much heat is wasted if office-hour temperatures are maintained during 24 hours for each day of the entire heating season. Office hours average about 50 per week, or about 1,500 per heating season. The heating season is approximately 5,040 hours, so that it becomes at once evident that much can be done toward reducing the overall heat cost in office buildings by lowering the temperatures during the hours of non-occupancy.

Third: Most large office buildings have more or less space occupied by merchants, and some by clubs, restaurants, etc., which have short hours of occupancy. Much can be accomplished in zoning with reference to the kind of occupancy of space.

There are other schemes employing various pressure devices for maintaining temperatures in radiators to meet controlled heat requirements.

Individual control on each heating unit is in wide use with thermostats and valves. Disregarding investment and operating cost, this system is ideal. However, when an open window permits cool air to touch the thermostat it must turn on the heat, defeating the purpose of the open window and resulting in overheating and waste.

Possibly some day all office windows will be sealed and all air will be brought to the rooms metered and washed and at the temperature desired, in which event, of course, there will be no open windows to upset the thermostats.

FACTORY HEATING

Automatic heat control in factories is of the greatest importance, since the most productive returns come from man power and this power is vitally influenced by the temperatures and condition of the air in the work rooms.

Window control of heat and ventilation is always wasteful, but may in some cases be justified, as for instance, where a factory generates its own electric or mechanical power by means of steam engines. The exhaust steam from engines may be sufficient at all times to supply the required heat. In fact, it may even be economical to waste considerable heat through the radiation to increase the efficiency of the engines generating the power by reducing back pressure.

Hot water, circulated mechanically, lends itself to factory heating where air conditioning is not a primary requirement. This is on account of the fact that the temperature of the heating medium can readily be raised and lowered at the central plant to meet the requirements. Unless some process work demands special temperature conditions and if the entire space can be given approximately the same temperatures, the control of temperatures may rest solely with the operator at the central plant when hot water is used.

If certain parts of the factory need higher temperatures than others, automatic heat control can readily be applied to both the direct and indirect distribution systems and can be subdivided to the most minute degree.

It is well to remember that if several heating units are controlled from one thermostat and the heating medium is steam, the thermostat, unless placed near the last radiator on the circuit, will tend to over-throttle the supply valves and finally will close them when the desired temperature has reached the thermostat and before the radiator has become warm. This may lead to complaint of uneven heating and to unfair criticism of the heating device or the thermostats.

Fig. 8 shows an arrangement of automatic control for a unit heater whereby thermostat No. 1 asks for heat, and passes electric current to motor valve No. 2, which operates, admitting steam to the heater. The same impulse from thermostat No. 1 also seeks to operate switch No. 3 and so to cause operation of the fan motor, but is prevented by contact thermostat No. 4 coiled around the return pipe of the heater. Thus unless the heater is warm its fan cannot operate and the ensuing cold drafts are avoided. As soon as the contact thermostat No. 4 becomes warm it permits operation of switch No. 3, starting the fan motor, and where desired also permits the motor damper operator No. 5 to open the intake damper from outside. The fan always stops and the damper always closes when the heater is cold.

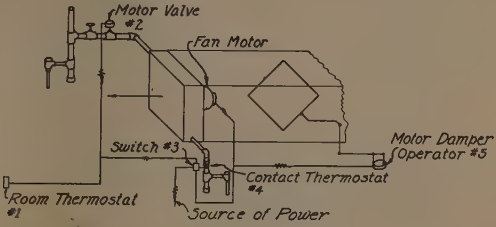


FIG. 8. ARRANGEMENT OF AUTOMATIC CONTROL FOR A UNIT HEATER

Electric heating finds many uses in factories where small spaces need higher temperatures than the average, or where heat is desired temporarily at times when the balance of the factory requires no heat or very little heat. Electric heating lends itself perfectly to automatic control, since its efficiency is 100 per cent, that is, every heat unit does useful work and there is no lead or lag due to accumulated heat in the radiator after the supply of energy is shut off. (See Chapter 13, Heating by Electricity).

THEATER HEATING

The modern theater requires temperature control of the most exacting type. Large volumes of air are handled. When this comes from outside it must be warmed or cooled and its moisture must be regulated. With the rapid air changes and the wide fluctuations in heat demand due to electric lights and varying intensity of occupation, there is a real necessity for automatic heat control.

The heat requirement curve of a modern theater will usually indicate the radiation working to maximum capacity one hour before the curtain rises and as the auditorium begins to fill with people this requirement curve rapidly drops until finally the curve crosses the zero line and cooling is required. The extent of this cooling depends on the outside temperature and on how many people are in the seats.

There are in successful theater air conditioning plants many thermostats, valves and dampers, all supplemented by expert manual supervision. The air conditioning apparatus involves refrigeration as well as heating, and is within the province of the thermal engineer. It is no field in which amateurs should practice.

GREENHOUSE HEATING

Heat control in greenhouse heating is practically the fundamental basis of the industry. Without some form of adequate thermostatic control, the man-hours required to maintain the rather exacting temperatures demanded by the growing of plants and flowers under glass would involve a prohibitive cost.

The system of heating employed is not in itself vitally important, although it is desirable to use a heating medium having a low temperature when the demands for heat are low. This assists materially in coordinating the artificial heat with the sun heat, that is, the temperature regulators can handle the artificial heat more exactingly if the temperature in the radiation is not greatly above that required to maintain the correct temperatures in the spaces to be heated.

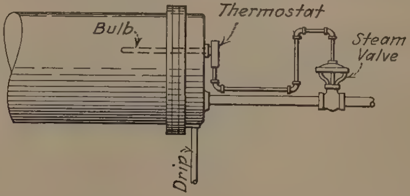


FIG. 9. THERMOSTAT ON STORAGE WATER HEATER

Sectional or zone heating should be employed in greenhouse work to a great degree, both with automatic control and with manual control. An experienced greenhouse engineer would divide the heating units in any given space into at least ten separate elements so that each kind of growing thing which may at various times be placed there can be given optimum conditions regardless of those out of doors.

In an industry where quality of product carries so much weight and where the ultimate purchaser usually is willing to pay for that distinctive quality, the cost of heat control to secure such quality is a minor consideration. (See Chapter 31, Special Heating and Ventilating Applications).

SWIMMING POOL HEATING

Swimming pools, to be acceptable in every way, require a considerable amount of heat, and while the temperature control need not be fine enough to split degrees, and while there are several ways of supplying the heat, a controlled supply of it must be maintained.

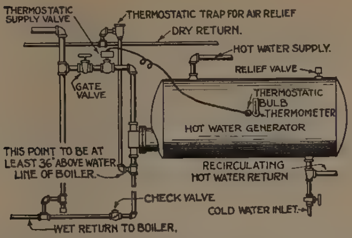


Fig. 10. Connecting Hot Water Generator to Low Pressure Gravity Return System Showing Automatic Control

The water in the pool may be circulated by means of a pump through a heat transfer tank in which it makes contact with correctly controlled hot surfaces such as steam coils.

The injection of steam directly into the water through a circulating arrangement may meet the requirement at a considerably lower cost for equipment and this can be controlled exactly.

When a directly-fired heater is used the draft dampers can be controlled automatically.

DOMESTIC HOT WATER HEATING

This is a class of heating as universal as that of house heating. Automatic control of the hot-water temperature as it leaves the heater is very essential to economy and to freedom from danger of scalding the bodies of the users of the water.

Domestic hot water must not reach steaming temperatures as these put a severe strain on the piping system and are very destructive to valves and valve packings. Every degree of excessive domestic hot-water temperature means wasted fuel.

When the water is heated with an individual heater, as for instance a small boiler with an automatic fuel burner, the thermostat in the supply or storage tank may control the burner direct. If the water is heated from a steam coil, the thermostat controls a valve which regulates the

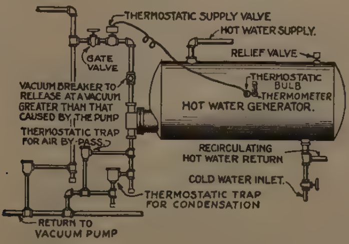

THERMOSTATIC SUPPLY VALVE
HOT WATER SUPPLY.
RELIEF VALVE
GATE VALVE
THERMOSTATIC BULB
THERMOMETER
HOT WATER GENERATOR.
VACUUM BREAKER TO RELEASE AT A VACUUM GREATER THAN THAT CAUSED BY THE PUMP
THERMOSTATIC TRAP FOR AIR BY-PASS.
RECIRCULATING HOT WATER RETURN
COLD WATER INLET.
THERMOSTATIC TRAP FOR CONDENSATION
RETURN TO VACUUM PUMP

Fig. 11. Connecting Hot Water Generator to Vacuum Pump System Showing Automatic Control

supply of steam. If the water is heated electrically, the thermostat throws an electric switch to control the heater elements.

Fig. 9 shows the thermostat and diaphragm valve on a storage water heater. The removable head of the heater has separate supply and return compartments which serve the heat transfer surfaces inside the tank, and which must be easily removable for cleaning. The supply piping must be provided with drains or traps arranged so that whether the steam valve shown in open or closed no condensation can accumulate ahead of it. A hand valve should be installed alongside the automatic valve. (See also Figs. 10 and 11).

When automatic fuel burners are employed, as in residences, the one burner through a system of controls readily may heat both the house and the hot water for domestic purposes. In most installations, this makes it unnecessary to install two separate fuel burners. Fig. 6 illustrates such a scheme.

BATH AND SHOWER CONTROL

The temperatures for the home bath or shower are usually controlled manually by mixing valves which combine the streams of water of different temperatures. In clubs and many hotels, as also in public buildings and factories, there has come into use, not only for convenience, but as a safety measure, thermostatic control at the showers of the mixing-valves to prevent excess temperatures.

MANUFACTURING

The ever-increasing demand for perfection in everything that contributes to the daily needs of a modern people is being met by the great host of manufacturers through the employment of *just the right heat* in the making of their products.

Factory-prepared foods and canned goods are invariably cooked or pasteurized at most exacting temperatures. A degree or two of excess heat may break down or otherwise impair the quality, while a very small margin of insufficient temperatures may permit many harmful organisms to remain alive in the food. The eternal vigilance of automatic heat control is an ever-increasing factor in the food industry.

Synthetic fabrics and other materials from which clothing are made go through temperature processes, which in many cases require fractional degree automatic heat control.

The manufacture and preservation of many building materials employing wood or vegetable fibres necessitate very high and carefully controlled temperatures. The ceramic industry which supplies all the earthenware creations found in our modern bathrooms is wholly dependent on the most exacting temperature regulation in the kilns. The slightest deviation from the right temperatures is sufficient to cause rejection of large percentages of the product.

A list of the manufactured articles which depend on automatic heat control for their production and perfection would include nearly everything which contributes to the pleasure and the profit of civilization.

CHAPTER 18

PIPE AND FITTINGS

Kinds of Pipe; Corrosion; Coatings; Cast Pipe; Wrought Iron Pipe; Thread Cutting; Welding Methods; Standards.

THE factors which control the characteristics and properties, and thus produce the modern improvement in various tubular materials, are the facilities of the manufacturer; the special processes employed; the availability and quality of raw materials and the ideals and skill of the men in the organization.

Ferrous Piping

Among modern improvements none have received greater attention than the efforts to produce a uniform quality of wrought pipe. To secure and maintain uniformity, necessitates complete control of all materials and manufacturing operations—from ore to finished product. This practice of producing uniform skelp and its fabrication into finished tubular products is supplemented by a mechanical process of roll-knobbing, to make the metal more uniformly dense when there is any tendency to physical irregularity in this respect.

Another condition which gives rise to electrolytic centers and pitting is the presence of irregular areas of heavy welding-scale on the surface of the finished product, caused by oxidation at the high temperature of welding. This scale is strongly electro-negative to iron, like copper, and should, therefore, be removed in the interest of preventing corrosion.

Other advantages of having the welding scale removed from pipe are: Its clean, smooth surfaces present an ideal base for the adherence of a galvanizing coating, full working capacity is assured (the interior being free from any obstructions tending to reduce the flow), troubles caused by the deposit of scale in valves, strainers, and other apparatus, are practically eliminated and pitting by corrosion is materially reduced.

Scale removal, where accomplished in the process of manufacture, is done by passing the oversize pipe through a series of finishing rolls (after its temperature has been reduced to about 1,800 deg. fahr.) which rolls reduce it to the proper size and also crack the hardened welding-scale from both the inside and the outside of the pipe. The loose scale is then washed or blown off. While with such expedients considerable improvement has been attained, the fact still remains that the life of pipe is governed largely by installation conditions, and no matter how well made or uniform the pipe may be, its life, particularly under severe corrosion conditions, such as must be met in hot water supply lines and in boiler feed and return lines, is limited, and some protective measures are necessary to secure a longer life.

Table 1. Standard Wrought Pipe

Table of Standard Dimensions

Size Inches	Diameters		Nominal Thickness Inches	Circumference		Transverse Areas			Length of Pipe per Square Foot of		Nominal Weight per Foot	
	External Inches	Approximate Internal Inches		External Inches	Internal Inches	External Sq. In.	Internal Sq. In.	Metal Sq. In.	External Surface	Internal Surface	Plain Ends	Threaded and Coupled
1/8	0.405	0.269	0.068	1.272	0.845	0.129	0.057	0.072	9.431	14.199	0.244	0.245
1/4	0.540	0.364	0.088	1.696	1.144	0.229	0.104	0.125	7.073	10.493	0.424	0.425
3/8	0.675	0.493	0.091	2.121	1.549	0.358	0.191	0.167	5.658	7.747	0.567	0.568
1/2	0.840	0.622	0.109	2.639	1.954	0.554	0.304	0.250	4.547	6.141	0.850	0.852
3/4	1.050	0.824	0.113	3.299	2.589	0.866	0.533	0.333	3.637	4.635	1.130	1.134
1	1.315	1.049	0.133	4.131	3.296	1.358	0.864	0.494	2.904	3.641	1.678	1.684
1¼	1.660	1.380	0.140	5.215	4.335	2.164	1.495	0.669	2.301	2.767	2.272	2.281
1½	1.900	1.610	0.145	5.969	5.058	2.835	2.036	0.799	2.010	2.372	2.717	2.731
2	2.375	2.067	0.154	7.461	6.494	4.430	3.355	1.075	1.608	1.847	3.652	3.678
2½	2.875	2.469	0.203	9.032	7.757	6.492	4.788	1.704	1.328	1.547	5.793	5.819
3	3.500	3.068	0.216	10.996	9.638	9.621	7.393	2.228	1.091	1.245	7.575	7.616
3½	4.000	3.548	0.226	12.566	11.146	12.566	9.886	2.680	0.954	1.076	9.109	9.202
4	4.500	4.026	0.237	14.137	12.648	15.904	12.730	3.174	0.848	0.948	10.790	10.889
5	5.563	5.047	0.258	17.477	15.856	24.306	20.006	4.300	0.686	0.756	14.617	14.810
6	6.625	6.065	0.280	20.813	19.054	34.472	28.891	5.581	0.576	0.629	18.974	19.185
8	8.625	8.071	0.277	27.096	25.356	58.426	51.161	7.265	0.442	0.473	24.696	25.000
8	8.625	7.981	0.322	27.096	25.073	58.426	50.027	8.399	0.442	0.478	28.554	28.809
9	9.625	8.941	0.342	30.238	28.089	72.760	62.786	9.974	0.396	0.427	33.907	34.188
10	10.750	10.192	0.279	33.772	32.019	90.763	81.585	9.178	0.355	0.374	31.201	32.000
10	10.750	10.136	0.307	33.772	31.843	90.763	80.691	10.072	0.355	0.376	34.240	35.000
10	10.750	10.020	0.365	33.772	31.479	90.763	78.855	11.908	0.355	0.381	40.483	41.132
11	11.750	11.000	0.375	36.914	34.558	108.434	95.033	13.401	0.325	0.347	45.557	46.247
12	12.750	12.090	0.330	40.055	37.982	127.676	114.800	12.876	0.299	0.315	43.773	45.000
12	12.750	12.000	0.375	40.055	37.699	127.676	113.097	14.579	0.299	0.318	49.562	50.706

Corrosion

The electrolytic theory of corrosion, as formulated in 1903 by Dr. Whitney, led to the development of certain protective methods for closed water systems, which are based on the removal of dissolved oxygen from the water. Careful experiments in various research laboratories have demonstrated that the amount of corrosion found in such systems is almost directly proportional to the amount of oxygen in solution, and varies with the temperature.

All reliable data on this subject indicate that the composition of the iron—*i.e.*, the varying amount of carbon, phosphorous, manganese, sulphur, silicon, oxides, slag and copper usually found in wrought iron and soft steel—makes very little difference in the amount or character of corrosion under water, although under atmospheric exposure the influence of composition is sometimes more marked.

In practice, oxygen removal has been accomplished in two ways, namely; by de-aerating the water mechanically; and by fixing the free oxygen by chemical combination. Suitable apparatus for this purpose is now on the market.

Protective Coatings

The introduction into piping systems of various chemical compounds, usually for forming a protective coating of thin deposit has apparently been rewarded with some success. Piping exposed to elements or buried in the ground is quite successfully protected by coatings of the ashphaltic type, usually applied hot.

Cast Metal Piping

There are available several types of cast ferrous metal piping made in special process to insure uniform wall thickness, which are believed to be exceedingly resistant to the agencies which so rapidly destroy wrought steel and iron piping used in heating systems.

Wrought Iron Piping

Genuine wrought iron piping has in many aged installations demonstrated superior resistance to corrosion.

Alloy Metal Piping

Claims of superiority are made for wrought steel piping bearing a small alloy of copper. These claims, however, have not received general recognition. They will, undoubtedly, be proved or disproved within a comparatively short time.

Thread Cutting

It is not usually practicable with threaded piping to screw all the threads into the fittings, so that there is left a raw metal cut, partly through the wall of the tube, inviting attack by outside influences. Welded or compression-flanged piping may have a longer life so far as attack from the exterior is concerned due to absence of this weak point.

Pipe Welding

The application of welding on the job gives to the heating industry an improved method of joining pipes.

TABLE 2. EXTRA STRONG WROUGHT PIPE

Table of Standard Dimensions

SIZE INCHES	DIAMETERS		NOMINAL THICKNESS INCHES	CIRCUMFERENCE		TRANSVERSE AREA			LENGTH OF PIPE PER SQUARE FOOT OF		LENGTH OF PIPE CONTAINING ONE CUBIC FOOT FEET	NOMINAL WEIGHT PER FOOT PLAIN ENDS POUNDS
	External Inches	Approximate Internal Inches		External Inches	Internal Inches	External Sq. In.	Internal Sq. In.	Metal Sq. In.	External Surface	Internal Surface		
⅛	0.405	0.215	0.095	1.272	0.675	0.129	0.036	0.093	9.431	17.766	3966.392	0.314
¼	0.540	0.302	0.119	1.696	0.949	0.229	0.072	0.157	7.073	12.648	2010.290	0.535
⅜	0.675	0.423	0.126	2.121	1.329	0.358	0.141	0.217	5.658	9.030	1024.689	0.738
½	0.840	0.546	0.147	2.639	1.715	0.554	0.234	0.320	4.547	6.995	615.017	1.087
¾	1.050	0.742	0.154	3.299	2.331	0.866	0.433	0.433	3.637	5.147	333.016	1.473
1	1.315	0.957	0.179	4.131	3.007	1.358	0.719	0.639	2.904	3.991	200.193	2.171
1¼	1.660	1.278	0.191	5.215	4.015	2.164	1.283	0.881	2.301	2.988	112.256	2.996
1½	1.900	1.500	0.200	5.969	4.712	2.835	1.767	1.068	2.010	2.546	81.487	3.631
2	2.375	1.939	0.218	7.461	6.092	4.430	2.953	1.477	1.608	1.969	48.766	5.022
2½	2.875	2.323	0.276	9.032	7.298	6.492	4.238	2.254	1.328	1.644	33.976	7.661
3	3.500	2.900	0.300	10.996	9.111	9.621	6.605	3.016	1.091	1.317	21.801	10.252
3½	4.000	3.364	0.318	12.566	10.568	12.566	8.888	3.678	0.954	1.135	16.202	12.505
4	4.500	3.826	0.337	14.137	12.020	15.904	11.497	4.407	0.848	0.998	12.525	14.[illegible]83
5	5.563	4.813	0.375	17.477	15.120	24.306	18.194	6.112	0.686	0.793	7.915	20.778
6	6.625	5.761	0.432	20.813	18.099	34.472	26.067	8.405	0.576	0.663	5.524	28.573
8	8.625	7.625	0.500	27.096	23.955	58.426	45.663	12.763	0.442	0.500	3.154	43.388
9	9.625	8.625	0.500	30.238	27.096	72.760	58.426	14.334	0.396	0.442	2.464	48.728
10	10.750	9.750	0.500	33.772	30.631	90.763	74.662	16.101	0.355	0.391	1.929	54.735
11	11.750	10.750	0.500	36.914	33.772	108.434	90.763	17.671	0.325	0.355	1.587	60.075
12	12.750	11.750	0.500	40.055	36.914	127.676	108.434	19.242	0.299	0.325	1.328	65.415

The oxy-acetylene torch, both for welding and for cutting, and the electric arc may be used to cut the pipe to the proper length and to bevel the ends for welding. It can also be used for cutting out the walls of the pipe to receive the branches.

The torch may be used for joining piping, both with lapped and butt welds and for welding branches into the main lines.

The electric arc may be used where welding is to be done on flanges, making a fillet weld.

Fittings often cause so much friction as to impair seriously the smooth and rapid transportation of the piped material. With the application of pipe bending and welds all branches and all changes in direction can be made with long sweep turns, greatly reducing friction at the bends.

Whenever a branch is joined to a main, templates should be used for cutting the hole through the wall of the main pipe and for preparing the end of the branch pipe. The branch pipe should not project inside the main but should fit snugly against the main so that with the process of welding no surplus metal will drop into the interior of the main.

When a branch is taken off from a main line and there is very little room for expansion it is good practice and very easy to weld in a reenforced brace between the branch and the main line. This is particularly true on large piping where high temperatures occur.

In changing the direction of the run of pipe it is better to use bends than to use fittings and nipples.

Special welding-fittings of uniform thickness are manufactured in all pipe sizes. These bends can be cut with the welding torch to any desired angle.

Welding rods of high grade material should be used on all welds. The more complicated the turn and the more severe the strain and service the better quality the rod must be.

Expert workmanship and correct engineering are of no avail if the welding rod is of improper character.

Steamfitters are now being trained as rapidly as possible in various schools throughout the country to handle the welding and cutting torch and to perform the electric arc weld. Since welding is a new industry there is some danger that failures may occur unless great care is taken with the workmanship.

The following rules are basic in welding practice and should be followed rigidly:

1. A skilled operator with the torch or arc, preferably a steamfitter, should be employed.

2. The proper welding rod and electrode must be supplied.

3. The choice of oxygen-acetylene or electric arc will be governed by the adaptability of each for the particular installation.

4. Templates shall be used for all cuts, with joints which are to be welded fitted closely, prior to starting the welding.

5. Standard welding tools and equipment of recognized make should be used.

The cost on small installations using welding is said to be higher than that using threaded fittings.

On large installations, however, it may generally be assumed that welding is less costly than threading.

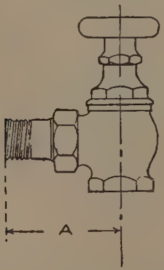
It is to be remembered that a considerable saving in weight is made where welding is used, due to the elimination of heavy cast iron fittings. An indirect saving due to welding is that resulting from the lighter supports and hangers required.

Non-Ferrous Piping

A recent development in the pipe trades is the use of copper tubing with compression fittings.

No threads are cut on the tubing, but the ends are expanded so as to fit against smooth spherical surfaces in the fittings, and are clamped there by a sleeve which may be screwed over the fitting, but which has no contact with the transported material inside the tube. The tube is thin enough to be bent readily, so that no elbow-fittings ordinarily are required. A typical example of this sort of piping and fittings is evidenced in the gasoline piping of any automobile.

It is possible that piping and fittings of the non-ferrous type may prove most satisfactory for comparatively large sizes and for heavy pressures and for rather high temperatures.



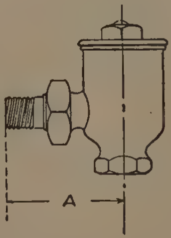


Table 3. Standard Roughing-in Dimensions

Angle Type Valves

Size of Valve	Dimension *A* Steam and Hot Water Angle Valves and Union Elbows Effective Jan. 1, 1926	Dimension *A* Modulating Valves Effective Jan. 1, 1926	Dimension *A* Return Line Vacuum Valves Effective Jan. 1, 1925
½″	2¼″	2¾″	3¼″
¾″	2¾″	2¾″	
1″	3″	3″	
1¼″	3½″	3½″	
1½″	3¾″	3¾″	
2″	4¼″	4¼″	
Tolerance	±⅛″	±⅛″	

The standardization of the Roughing-in Dimensions of Angle Steam and Hot Water, and Modulating Radiator Valves was made possible by the cooperation of the Manufacturers Standardization Society of the Valves and Fittings Industry.

Expansion and Contraction

In all piping systems which are subject to temperature variation provision must be made for adequate anchorages with expansion and contraction arrangements between them.

In designing any system of steam or hot water piping the expansion for each straight run should be calculated and allowed for.

All risers must be anchored and safeguarded so that the difference in length when hot from the length when cold shall not disarrange the normal and orderly provisions for drainage of the branches.

It is especially necessary with ultra-modern light-weight radiators so

125 LB. CAST IRON SCREWED FITTINGS

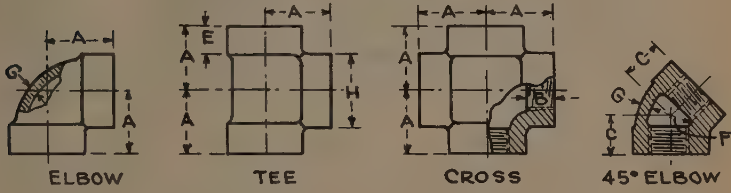


TABLE 4. DIMENSIONS OF ELBOWS, 45 DEG. ELBOWS, TEES, AND CROSSES (STRAIGHT SIZES)

	A	*C*	*B*	*E*	*F*		*G*	*H*
NOMINAL PIPE SIZE	CENTER TO END, ELBOWS, TEES AND CROSSES	CENTER TO END, 45 DEG. ELBOWS	LENGTH OF THREAD MIN.	WIDTH OF BAND, MIN.	INSIDE DIAMETER OF FITTING		METAL THICKNESS, MIN.	OUTSIDE DIAMETER OF BAND, MIN.
					Min.	Max.		
¼	0.81	0.73	0.32	0.38	0.540	0.584	0.110	0.93
⅜	0.95	0.80	0.36	0.44	0.675	0.719	0.120	1.12
½	1.12	0.88	0.43	0.50	0.840	0.897	0.130	1.34
¾	1.31	0.98	0.50	0.56	1.050	1.107	0.155	1.63
1	1.50	1.12	0.58	0.62	1.315	1.385	0.170	1.95
1¼	1.75	1.29	0.67	0.69	1.660	1.730	0.185	2.39
1½	1.94	1.43	0.70	0.75	1.900	1.970	0.200	2.68
2	2.25	1.68	0.75	0.84	2.375	2.445	0.220	3.28
2½	2.70	1.95	0.92	0.94	2.875	2.975	0.240	3.86
3	3.08	2.17	0.98	1.00	3.500	3.600	0.260	4.62
3½	3.42	2.39	1.03	1.06	4.000	4.100	0.280	5.20
4	3.79	2.61	1.08	1.12	4.500	4.600	0.310	5.79
5	4.50	3.05	1.18	1.18	5.563	5.663	0.380	7.05
6	5.13	3.46	1.28	1.28	6.625	6.725	0.430	8.28
8	6.56	4.28	1.47	1.47	8.625	8.725	0.550	10.63
10	8.08	5.16	1.68	1.68	10.750	10.850	0.690	13.12
12	9.50	5.97	1.88	1.88	12.750	12.850	0.800	15.47
14 O.D.	10.40	....	2.00	2.00	14.000	14.100	0.880	16.94
16 O.D.	11.82	....	2.20	2.20	16.000	16.100	1.000	19.30

All dimensions given in inches.

Dimensions for reducing elbows and reducing tees are given in Table 2 and Table 3, respectively.

to anchor and so to give freedom for expansion of the piping that no strain therefrom shall be allowed to distort the radiators. When expansion strains from the pipes are permitted to reach these light metal heaters they usually emit sounds of distress which are exceedingly troublesome.

Standards

Several tables of standard dimensions of piping and fittings are appended.

125 LB. CAST IRON FLANGED FITTINGS

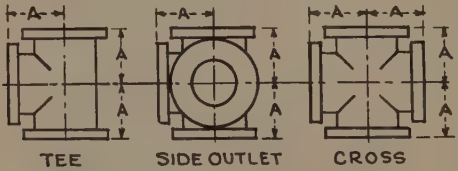


TABLE 5. DIMENSIONS OF TEES AND CROSSES (STRAIGHT SIZES)

NOMINAL PIPE SIZE[a-b]	A	AA	DIAMETER OF FLANGE	THICKNESS OF FLANGE, MIN.	METAL THICKNESS OF BODY, MIN.
	CENTER TO FACE TEES AND CROSSES[b-c]	FACE TO FACE TEES AND CROSSES[b-c]			
1	3½	7	4¼	7/16	7/16
1¼	3¾	7½	4⅝	½	7/16
1½	4	8	5	9/16	7/16
2	4½	9	6	⅝	7/16
2½	5	10	7	11/16	7/16
3	5½	11	7½	¾	7/16
3½	6	12	8½	13/16	7/16
4	6½	13	9	15/16	½
5	7½	15	10	15/16	½
6	8	16	11	1	9/16
8	9	18	13½	1⅛	⅝
10	11	22	16	1 3/16	¾
12	12	24	19	1¼	13/16
14 O.D.	14	28	21	1⅜	⅞
16 O.D.	15	30	23½	1 7/16	1
18 O.D.	16½	33	25	1 9/16	1 1/16
20 O.D.	18	36	27½	1 11/16	1⅛
24 O.D.	22	44	32	1⅞	1¼
30 O.D.	25	50	38¾	2⅛	1 7/16
36 O.D.	28	56	46	2⅜	1⅝
42 O.D.	31	62	53	2⅝	1 13/16
48 O.D.	34	68	59½	2¾	2

All dimensions given in inches.

[a] Size of all fittings listed indicates nominal inside diameter of port.

[b] Tees, side outlet tees, and crosses, 16 in. and smaller, reducing on the outlet, have the same dimensions center to face, and face to face as straight size fittings, corresponding to the size of the larger opening. Sizes 18 in. and larger, reducing on the outlet, are made in two lengths, depending on the size of the outlet as given in Table 9.

[c] Tees and crosses, reducing on run only, carry same dimensions center to face and face to face as a straight size fitting of the larger opening.

Table 1 is for standard wrought pipe and Table 2 is for extra strong wrought pipe.

Standard roughing-in dimensions for angle type valves are given in Table 3.

The dimensions of elbows, tees and crosses for 125 lb. cast iron screwed fittings are given in Table 4, whereas the dimensions of tees and crosses for 125 lb. cast iron flange fittings are given in Table 5.

Table 7 gives the dimensions of welding neck flanges for standard pipe.

125 LB. CAST IRON FLANGED FITTINGS

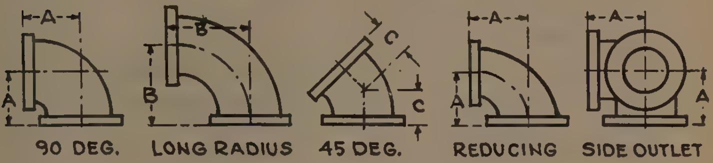


TABLE 6. DIMENSIONS OF ELBOWS

NOMINAL PIPE SIZE[a]	A	B	C	DIAMETER OF FLANGE	THICKNESS OF FLANGE, MIN.	METAL THICKNESS OF BODY, MIN.
	CENTER TO FACE ELBOW[b-c-d]	CENTER TO FACE LONG RADIUS ELBOW[b-c-d]	CENTER TO FACE 45 DEG. ELBOW[c]			
1	3½	5	1¾	4¼	7/16	7/16
1¼	3¾	5½	2	4⅝	½	7/16
1½	4	6	2¼	5	9/16	7/16
2	4½	6½	2½	6	⅝	7/16
2½	5	7	3	7	11/16	7/16
3	5½	7¾	3	7½	¾	7/16
3½	6	8½	3½	8½	13/16	7/16
4	6½	9	4	9	15/16	½
5	7½	10¼	4½	10	15/16	½
6	8	11½	5	11	1	9/16
8	9	14	5½	13½	1⅛	⅝
10	11	16½	6½	16	1 3/16	¾
12	12	19	7½	19	1¼	13/16
14 O.D.	14	21½	7½	21	1⅜	⅞
16 O.D.	15	24	8	23½	1 7/16	1
18 O.D.	16½	26½	8½	25	1 9/16	1 1/16
20 O.D.	18	29	9½	27½	1 11/16	1⅛
24 O.D.	22	34	11	32	1⅞	1¼
30 O.D.	25	41½	15	38¾	2⅛	1 7/16
36 O.D.	28	49	18	46	2⅜	1⅝
42 O.D.	31	56½	21	53	2⅝	1 13/16
48 O.D.	34	64	24	59½	2¾	2

All dimensions given in inches.

[a] Size of all fittings listed indicates nominal inside diameter of port.

[b] Reducing elbows and side outlet elbows carry same dimensions center to face as straight size elbows, corresponding to the size of the larger opening.

[c] Special degree elbows, ranging from 1 to 45 deg., inclusive, have the same center to face dimensions given in 45 deg. elbows and those over 45 deg. and up to 90 deg. inclusive, shall have the same center to face dimensions given for 90 deg. elbows. The angle designation of an elbow is its deflection from straight line flow and is the angle between the flange faces.

[d] Side outlet elbows shall have all openings on intersecting center-lines.

The dimensions of elbows for 125 lb. cast iron flange fittings are shown in Table 6.

Testing Pipe

Pressure tests of pipe are commonly made in order to show the presence of flaws or other defects in the weld or body of the pipe. Wrought pipe, as distinguished from seamless tubing, is either butt- or lap-welded; sizes up to and including 1¼ in. being made by the former, and those 1½ in. and larger by the latter process. Lap-welded pipe, 1½ in. diameter, may safely be tested to 2,500 lb. per square inch cold hydraulic pressure, while 12 in. diameter pipe should not be tested to more than 300 lb. per square inch. The makers vary the test pressure in accordance with the diameter so as to produce approximately the same fiber stress in each size of pipe.

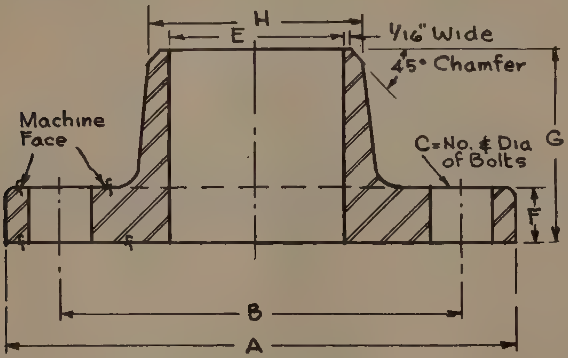


TABLE 7. DIMENSIONS OF WELDING NECK FLANGES FOR STANDARD PIPE[b]

NOMINAL PIPE SIZE	A	DRILLING		E	F	G	H
		B	C	STANDARD PIPE			
2	6	4¾	4– ⅝	2 1/16	⅝	2½	2½
2½	7	5½	4– ⅝	2 15/32	11/16	2¾	3
3	7½	6	4– ⅝	3 1/16	¾	2¾	3⅝
4	9	7½	8– ⅝	4 1/32	15/16	3	4⅝
5	10	8½	8– ¾	5 1/16	15/16	3½	5 11/16
6	11	9½	8– ¾	6 1/16	1	3½	6¾
8	13½	11¾	8– ¾	8	1⅛	4	8¾
10	16	14¼	12– ⅞	10	1 3/16	4	10⅞
12	19	17	12– ⅞	12	1¼	4½	12⅞
14 O.D.	21	18¾	12–1	[a]	1⅜	5	14 3/16
16 O.D.	23½	21¼	16–1	[a]	1 7/16	5	16¼
18 O.D.	25	22¾	16–1⅛	[a]	1 9/16	5½	18¼

All dimensions given in inches.

[a] Orders or inquiries should specify diameter of bore "*E*" required.

[b] Copyright, 1929, by *Heating and Piping Contractors National Association.*

CHAPTER 19

PUMPS AND TRAPS

Boiler Feed Pumps; Automatic Pumps and Receivers; Centrifugal Pumps; Vacuum Heating Pumps.

THE pumps used in connection with heating and ventilating installations may be classified as follows:

1. Boiler Feed Pumps.
2. Condensation Return Pumps.
3. Return Line Vacuum Heating Pumps.
4. Forced Circulation Hot Water Heating Pumps.
5. Circulating Pumps for Water, Brine, etc.
6. Refrigeration Pumps and Compressors.

BOILER FEED PUMPS

Boiler feed pumps may be (1) direct acting steam-driven reciprocating pumps; (2) power driven reciprocating pumps; (3) centrifugal pumps; (4) screw or other similar type pumps.

Capacities

The capacity of a boiler feed pump should be based on 34.5 lb. of water per hour per maximum boiler horsepower served, with a slippage allowance of 10 per cent in the water cylinders and a factor of safety allowance of two for intermittently operating pumps and one and one-half for continuously operating pumps, to provide for unusual conditions, such as low water in boilers, drop in steam pressure or excessive loads.

Piston Speeds and Efficiencies

For reciprocating boiler feed pumps the speed should not exceed 10 times the square root of the number of inches in the length of stroke of the water pistons.

Direct-acting reciprocating steam-driven or power-driven boiler feed pumps are generally more efficient for smaller installations, especially with widely fluctuating loads as efficiencies of centrifugal boiler feed type drop off very rapidly for the smaller sizes of pumps and for low-load conditions. For this reason centrifugal pumps are not usually employed for installations of less than 1,000 boiler horsepower.

The capacities and pressures at which screw pumps will operate is almost infinite. They may be used with good economy for small capacities. Efficiencies range from 60 to 70 per cent.

The volumetric displacement rate of water pistons should not be less than twice the maximum rate of flow of the condensate to be handled.

The quantities of condensate to be handled from direct radiation, direct-indirect radiation and indirect or fan blast radiation may be estimated as follows:

For direct radiation $W = 0.3\ R$[1]

For direct-indirect radiation $W = 0.6\ R$[1]

For indirect radiation $W = \dfrac{Q \times 60 \times T}{55.6 \times r}$

where

W = pounds of condensate per hour.
R = square feet of radiation.
Q = cubic feet of air per minute.
T = temperature rise of air in deg. fahr.
r = the latent heat of steam in the system in B.t.u. per pound.

CONDENSATION PUMPS

Condensation return pumps are generally of two types: (1) automatic pumps and receivers, and (2) continuously operating non-automatic return pumps. These may be of the steam or power driven reciprocating type or motor-driven centrifugal type. Steam and power-driven reciprocating condensation pumps should always be of the automatic type.

TABLE 1. HORIZONTAL STEAM DRIVEN SIMPLEX RECIPROCATING BOILER FEED PUMPS—150 LB. WORKING PRESSURE

CYLINDER SIZES INCHES			PIPE SIZES INCHES				CAPACITY IN GALLONS PER STROKE	BOILER HORSEPOWER PUMP WILL FEED AT MODERATE SPEED
Steam	Water	Stroke	Steam	Exhaust	Suction	Delivery		
2½	1⅜	2	¼	⅜	¾	½	0.013	20
3	1¾	2½	⅜	½	1	¾	0.020	35
4	2⅜	3	⅜	¾	1¼	¾	0.058	60
4	2½	6	⅜	¾	2	1¼	0.128	100
5	3	6	½	¾	2	1¼	0.184	150
5½	3½	6	¾	1	2	1½	0.250	200
6	3⅝	8	¾	1	2½	2	0.360	250
6	4	8	¾	1	2½	2	0.435	300
7	4	8	1	1¼	2½	2	0.435	350
8	5	8	1	1½	3	2½	0.675	450
7	4½	10	1	1¼	3½	2½	0.688	400
7½	4½	10	1	1¼	3½	2½	0.688	450
8	5	10	1	1½	3½	2½	0.850	500
8	5	12	1	1½	4	3	1.02	600
10	6	12	1¼	1½	4	3	1.469	1,000
12	7¼	12	1½	2	5	4	2.144	1,500
12	8	12	1½	2	5	4	2.611	1,650
14	8½	12	2	2½	6	5	2.948	2,000
16	9¼	16	3	3½	8	7	4.656	2,200
16	10	16	3	3½	8	7	5.441	2,500
16	9¼	20	3	3½	8	7	5.820	2,400
16	10	20	3	3½	8	7	6.801	2,700
20	12	20	3½	4	8	7	9.794	3,500

---

[1] This is greater than the standard 0.25 lb. of condensate per square foot, to take care of heating-up periods.

Automatic Pumps and Receivers

The *volumetric capacity* of receivers for electrically-driven pumps should be not less than twice the maximum minute volumetric flow of condensation to be handled, measured between the high and low water lines in the receiver. For steam-driven pumps and receivers, the capacity may be less than for electrically-driven pumps.

Table 2. Horizontal Steam Driven Duplex Reciprocating Boiler Feed Pumps—150 Lb. Working Pressure

Cylinder Sizes Inches			Pipe Sizes Inches				Gallons per Stroke Each Piston	Boiler Horsepower Based on 34.5 Lb. Evaporation—No Factor of Safety	No. of Strokes per Minute	Discharge in Gallons
Steam	Water	Stroke	Steam	Exhaust	Suction	Discharge				
3	2	3	⅜	½	1¼	1	0.04	83	70	5.6
4	2½	4	½	¾	2	1½	0.08	150	60	9.6
4½	2¾	4	½	¾	2	1½	0.103	180	60	12.0
5¼	3½	5	1	1¼	2½	1½	0.208	330	50	20.0
6	4	6	1	1½	3	2	0.33	470	50	33.0
7	4½	8	1¼	1½	4	3	0.55	760	50	55.0
7½	4½	10	1½	2	4	3	0.69	840	40	55.2
8	5	10	1½	2	4	3	0.85	1,100	40	68.0
10	6	10	2	2½	5	4	1.22	1,600	40	97.6
12	7	12	2½	3	6	5	1.99	2,300	35	139.3

Table 3. Horizontal Duplex Power Driven Boiler Feed Pumps—150 Lb. Working Pressure

Cylinder Sizes, Inches		Maximum R. P. M. Crank Shaft	Displacement Gallons per Revolution	Gallons per Minute	Brake[a] Horsepower Required at 150 lb. Pressure	Boiler Horsepower Served Without Safety Factor	Pipe Sizes Inches		Pulley Sizes Inches and R. P. M.		
Diam.	Stroke						Suction	Disch.	Diam.	Face	R. P. M.
2¾	4	60	0.41	24	2.1	330	2½	2	14½	2½	300
3	4	60	0.48	28	2.46	390	2½	2	14½	2½	300
3½	6	50	0.99	59	5.2	820	3	2	25	5	250
4	6	55	1.32	79	6.96	1,010	4	3	25	5	275
4½	8	45	2.19	110	9.65	1,520	4	3	30	5	225
5	10	40	3.40	136	11.97	1,890	4	3	37	8	200
5½	10	40	4.11	164	14.45	2,280	5	4	37	8	200
6	10	40	4.88	195	17.17	2,700	5	4	37	8	200

[a] Figure pump efficiency at 50 per cent to arrive at motor horsepower to be used.

The piston speed in feet per minute should not be more than 10 times the square root of the number of inches in the length of stroke.

The volumetric displacement rate of water pistons should not be less than three times the maximum volumetric rate of the flow of condensate to be handled.

The normal capacity of centrifugal pumps should not be less than twice the maximum rate of flow of the condensate to be handled.

Table 4. Sizes, Revolutions per Minute, Heads, Power Required and Boiler Horsepower for Several Commercial Sizes of Centrifugal Type Boiler Feed Pumps

Size of Pump Inches	Brake Horsepower	Pipe Sizes, Inches		Capacity Gallons per Minute	Boiler Horsepower Served Without Safety Factor
		Suction	Discharge		
Two Stage for 100 lb. Working Pressure					
2	13.3	2½	2	100	1,450
2½	16.9	3	2½	150	2,175
3	23.6	4	3	225	3,262
4	37.2	6	4	400	5,800
5	57.0	7	5	620	8,990
6	76.5	8	6	900	13,000
Three Stage for 150 lb. Working Pressure					
2	19.9	2½	2	100	1,450
3	35.4	4	3	225	3,262
4	55.8	6	4	400	5,800
5	85.5	7	5	620	8,990
6	114.7	8	6	900	13,000
Four Stage for 200 lb. Working Pressure					
2	33.2	2½	2	100	1,450
3	59.0	4	3	225	3,262
4	93.0	6	4	400	5,800
5	143.0	7	5	620	8,990
6	192.0	8	6	900	13,000

Table 5. Screw Pumps

Size of Pump Inches	Gallons per Minute	Maximum Revolutions	Suction Inches	Discharge Inches
2	2– 15	1,600	2	1½
2½	10– 20	1,600	2	1½
3	20– 50	1,600	2½	2½
3¼	40– 60	1,600	3	2½
3½	55– 100	1,500	4	3
4	85– 200	1,400	4	4
5	175– 275	1,200	5	4
5¼	200– 325	1,200	5	4
6	275– 475	1,200	6	6
7	300– 600	1,000	8	6
8	450– 750	875	8	8
9	700–1000	720	10	10
10	800–1400	700	12	12
12	1200–2100	600	14	14
16	1750–4200	425	16	15

Continuously Operating Return Pumps

The piston speed in feet per minute should not be more than 10 times the square root of the number of inches in the length of stroke.

The normal capacity of standard centrifugal pumps should be based on condensate at a temperature of not over 180 deg. fahr. For temperatures of condensate above this the capacity should be increased as in Table 6.

The increase in pump capacity may be reduced if a static head above the pump suction is provided. When this static head is made equivalent to the absolute boiling pressure of the condensate (measured in feet of water) minus 12 ft., no increase in pump capacity is required.

TABLE 6. CORRECTION FACTORS FOR STANDARD CENTRIFUGAL PUMPS FOR TEMPERATURES OF CONDENSATE ABOVE 180 DEG. FAHR. AT PUMP SUCTION

DEG. FAHR.		FACTOR
190		1.15
200		1.56
204		2.00

Note.—To use this Table, multiply the quantity of condensate to be handled by the factor corresponding to the temperature of the condensate at the pump suction and select a pump for the quantity thus found.

TABLE 7. SIMPLEX PISTON TYPE STEAM DRIVEN CONDENSATION PUMP AND RECEIVERS

CYLINDER SIZES INCHES			PIPE SIZES INCHES				DRAINING CAPACITY	
Steam	Water	Stroke	Steam	Exhaust	Inlet	Delivery	Square Feet	1 IN. PIPE
2½	1⅜	2	¼	⅜	2	½	1,000	3,000
3	1¾	2½	⅜	½	2	¾	2,000	6,000
4	2⅜	3	⅜	¾	2	¾	3,000	9,000
5	3	3½	½	¾	2	1	4,500	13,500
5	3	6	½	¾	2	1¼	7,500	22,500
5½	3½	6	¾	1	2	1½	9,000	27,000
6	3⅝	8	¾	1	2½	2	13,000	39,000
6	4	8	¾	1	2½	2	15,000	45,000
7	4	8	1	1¼	2½	2	15,000	45,000
8	5	10	1	1½	3½	2½	27,000	81,000
10	6	12	1¼	1½	4	3	40,000	120,000
12	7¼	12	1½	2	5	4	65,000	195,000
12	8	12	1½	2	5	4	70,000	210,000

This static suction head requirement may also be reduced about 50 per cent when special large suction inlets or special impellers are provided.

Sufficient head in addition to the total head necessary to overcome static head, velocity head, pipe friction and boiler pressure should be provided wherever condensate is to be returned directly to a boiler from the pump.

VACUUM HEATING PUMPS

Return-line vacuum heating pumps may be of the following types:

1. Direct-acting reciprocating steam-driven return-line vacuum pumps.
2. Reciprocating power-driven return-line vacuum pumps.
3. Motor-driven return-line vacuum pumps of the centrifugal or rotary type having one of the following arrangements:
    (*a*) One pumping unit and motor for handling both air and condensate.
    (*b*) One pumping unit and motor for handling air and a separate pumping unit and motor for handling condensate.

TABLE 8. DUPLEX PISTON TYPE STEAM-DRIVEN PUMP AND RECEIVERS

30 lb. Pressure

SIZE OF PUMP INCHES	SIZE OF RECEIVER INCHES	SQUARE FEET OF DIRECT RADIATION	PIPE SIZES, INCHES			
			Steam	Exhaust	Suction	Discharge
3 x 2 x 3	12 x 23	5,000	⅜	½	1¼	1
4½ x 2¾ x 4	12 x 23	10,000	½	¾	2	1½
5¼ x 3½ x 5	16 x 32	20,000	1	1¼	2½	1½
6 x 4 x 6	16 x 32	40,000	1	1½	3	2
7 x 4½ x 8	20 x 43	60,000	1¼	1½	4	3
8 x 5 x 10	24 x 46	90,000	1½	2	4	3

10 lb. Pressure

SIZE OF PUMP INCHES	SIZE OF RECEIVER INCHES	SQUARE FEET OF DIRECT RADIATION	PIPE SIZES, INCHES			
			Steam	Exhaust	Suction	Discharge
4½ x 2 x 4	12 x 23	6,000	½	¾	2	1½
5¼ x 2¼ x 5	12 x 23	9,000	1	1¼	2½	1½
6 x 2½ x 6	16 x 32	16,000	1	1½	3	2
7 x 3 x 8	16 x 32	25,000	1¼	1½	4	3
8 x 3½ x 10	20 x 43	45,000	1½	2	4	3
10 x 4½ x 10	24 x 46	70,000	2	2½	5	4

TABLE 9. CHARACTERISTICS OF CENTRIFUGAL RETURN PUMPS AND RECEIVERS DELIVERING AGAINST VARIOUS PRESSURES

RATING SQUARE FEET EQUIVALENT CAST IRON DIRECT RADIATION	ACTUAL MEASURED WATER CAPACITY GALLONS PER MINUTE	MOTOR HORSEPOWERS DISCHARGE PRESSURE, POUNDS PER SQUARE INCH AT PUMP					
		10 lb.	20 lb.	30 lb.	40 lb.	50 lb.	60 lb.
2,000	4	⅓	½	¾	1	1	2
4,000	6	⅓	½	¾	1	1	2
6,000	8	⅓	½	¾	1	1½	2
8,000	11	⅓	½	¾	1	1½	2
10,000	13	⅓	½	¾	1	1½	2
12,000	16	½	¾	1	1½	1½	...
16,000	22	½	¾	1	1½	1½	...
26,000	35	¾	1	1½	3	5	7½
40,000	60	1½	2	3	5	7½	10
65,000	90	1½	3	5	5	7½	10
100,000	150	2	5	7½	7½	10	15
150,000	200	3	5	7½	10	15	15

(*c*) One pumping unit and motor for handling condensate with an air ejector operated by a recirculated portion of the condensate for handling the air.
(*d*) One pumping unit for handling condensate and another for handling the air, both operated by one motor.

The volumetric displacement rate of the water cylinders of steam or power-driven reciprocating return-line vacuum pumps should be from 8 to 10 times the volumetric rate of flow of the condensate to be handled.

The piston speed in feet per minute of steam reciprocating return-line vacuum pumps should not be more than 20 times the square root of the number of inches in the length of stroke.

The speed of crank shafts of power-driven reciprocating return-line vacuum pumps should not exceed the following:

LENGTH OF STROKE INCHES	MAXIMUM CRANK SHAFT SPEED R. P. M.
3	80
6	50
8	50
12	40
20	25

The type of drive to be employed between motor and pump may be chain, belt or gear. When gears are used they should be of a type which will be quiet in operation.

The receiving tank may be placed either on the suction or on the discharge side of the pump; generally on the suction side.

The capacity of receiving tanks, when placed on the suction side of pumps, should be proportioned to the operating condition to be met. To this end its capacity should be such as to retain the condensate and to take care of fluctuations between the rate of returning condensate and the rate of the pump delivery. This capacity in case of automatically controlled units should be the capacity of the tank in gallons between the high and low water levels in the tank, as determined by the water-line control, and when not otherwise provided for, should be in accordance with Table 10.

TABLE 10. RECEIVER TANK CAPACITIES FOR CENTRIFUGAL OR ROTARY VACUUM HEATING PUMPS

SQUARE FEET EQUIVALENT DIRECT CAST IRON RADIATION	TOTAL RECEIVER TANK CAPACITY IN GALLONS	RECEIVER TANK CAPACITY BETWEEN HIGH AND LOW WATER LIMITS WHERE AUTOMATIC WATER LINE CONTROL IS USED
2,500	6	6
5,000	6	6
8,000	28	20
16,000	33	27
26,000	47	34
40,000	55	44
65,000	69	54
100,000	80	63

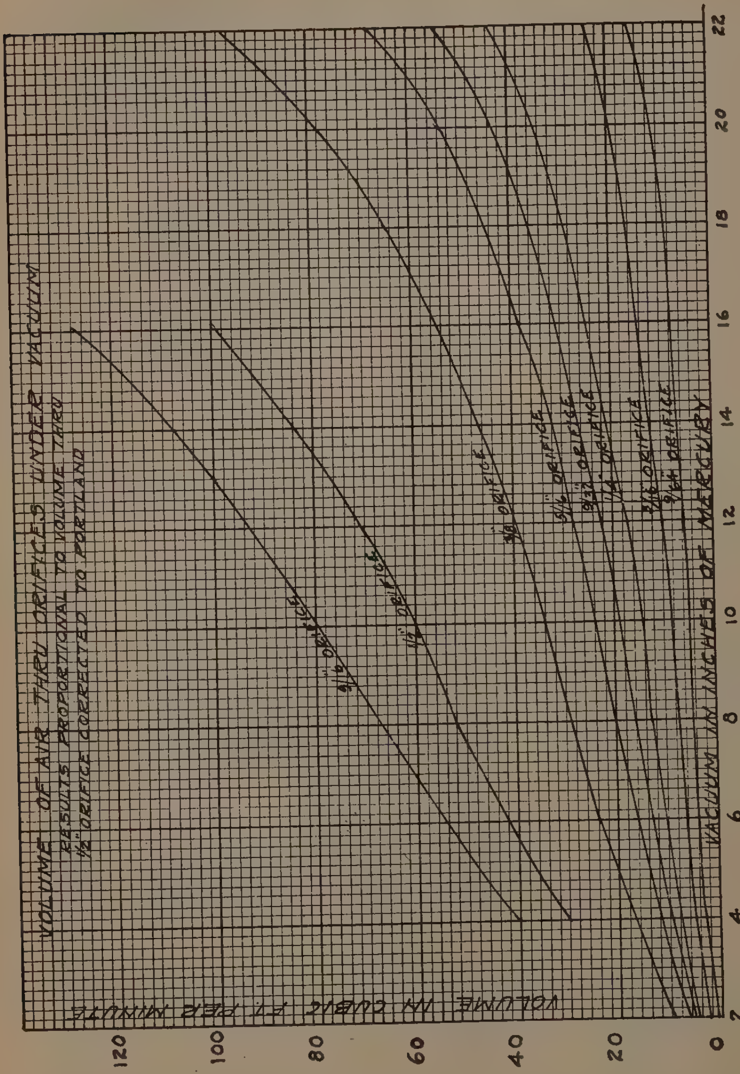


Fig. 1. Volume of Air through Orifices under Vacuum

Air capacities of vacuum heating pumps are in general referred to as equivalent cast iron direct radiation, and may be assumed on a decreasing ratio as the system increases in capacity, in accordance with Table 11. It should be noted that while water capacities of pumps for fan blast heaters are to be based upon their equivalent in direct radiation the air capacities for this class of radiation may be considerably less than that corresponding to this equivalent.

The air capacity measurement of a vacuum heating pump should be made at a point in the main vacuum return line close to and before it enters the pump strainer, while the pump is in operation, under the vacuum specified at the pump suction and while handling the quantity of condensate specified at a temperature not exceeding 180 deg. fahr.

TABLE 11. AIR CAPACITIES FOR VACUUM HEATING PUMPS

SQUARE FEET DIRECT EQUIVALENT RADIATION SURFACE	DIAMETER ORIFICE VACUUM 10 IN.	AIR CAPACITY CUBIC FEET PER MINUTE
2,500	3/32″	3
5,000	7/64″	3
8,000	9/64″	5
16,000	3/16″	9
26,000	1/4	15
40,000	9/32″	19
65,000	3/8″	34
100,000	13/32″	44
150,000	9/16″	80
300,000	Three (3) 13/32″	132

Air test in general may be made with water at lower temperatures; these determinations shall be made by means of a standard test orifice located in an inlet connection to the pump suction, consisting of a plate ⅛ in. thick with a reamed hole having sharp edges and of a diameter corresponding to the capacity of the pump.

Fig. 1 may be used to give the quantity of air handled, corresponding to several sizes of orifices and different degrees of vacuum to be met.

The water capacity of vacuum heating pumps, when operating against 8 in. of mercury vacuum, should be not less than ⅔ lb. of water per hour per square foot of equivalent cast iron direct radiation, based upon condensate at a temperature of not over 180 deg. fahr. when the pump is delivering water against a specified gage pressure at the water discharge of the pump. For pumps handling both air and water the above water capacity must be delivered when the pump is maintaining a vacuum of 8 in. of mercury and handling air through a standard orifice corresponding to the air capacity of the pump as herein specified.

In estimating the water capacity no additional allowance need be made for covered mains or risers, but exposed mains or risers used as heating surfaces should be included in computing the equivalent square foot of direct radiation.

Steam-driven vacuum pump size determination should take into consideration the following variables:

(*a*) The degree of tightness of system; (*b*) the efficiency of the radiator traps; (*c*) the temperature of the condensate at the pump; (*d*) the probable cooling effect of the return piping; (*e*) the use of lift points in the return; (*f*) vacuum to be maintained at the pump; (*g*) introduction of large volumes of high temperature water into the return piping near the pump; (*h*) the use of long runs of piping from the source of steam supply to the farthest radiator.

High-pressure traps should not discharge directly into a vacuum return because of the vapor formed by the re-evaporation of a part of the hot condensation.

Fig. 2 shows one method which may be used for disposing of the greater part of the vapor of re-evaporation.

Steam-driven pumps can be economically used with steam pressures of 15 lb. or over and where the exhaust steam can be completely utilized.

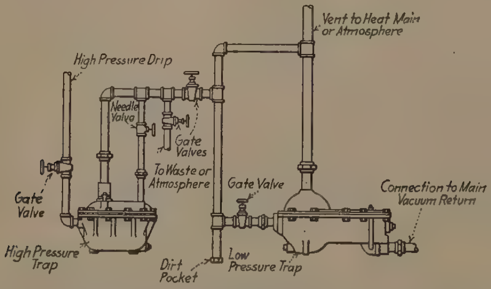


FIG. 2. METHOD OF DISCHARGING HIGH-PRESSURE APPARATUS INTO LOW-PRESSURE HEATING MAINS AND VACUUM RETURN MAINS THROUGH A LOW-PRESSURE TRAP

Where the supply of exhaust steam from engines or other sources is continuously in excess of that necessary to supply the heating system the electric-driven pump is generally the most efficient and is also preferable when the steam pressure is too low to operate a steam-driven pump.

Steam cylinder sizes of reciprocating vacuum pumps should include the effect of frictional resistance of the piping system, the pump resistance and the possible drop in steam pressure under unusual conditions. When this analysis is not feasible the following formula may be used:

$$A_s = A_w\, 3\left(\frac{\frac{V}{2} - P_d}{P_b}\right)$$

in which

A_s = area of steam piston in square inches.
A_w = area of water piston in square inches.
P_b = boiler pressure in pounds per square inch.
P_d = discharge pressure in pounds per square inch.
V = vacuum at pump expressed in inches of mercury.
$\frac{V}{2}$ = approximate vacuum in pounds per square inch (2 in. mercury = approximately 1 lb. per square inch).

Water cylinder sizes of steam-driven reciprocating vacuum heating pumps may be determined from Table 12.

The discharge from reciprocating vacuum heating pumps should be provided with means for releasing the entrained air. This may require water surface area in either a tank having a large horizontal cross-section or a stand pipe of sufficient sectional area to permit a low velocity of downward water flow while the entrained air is escaping to the surface against the water current. For removal of air in a separating tank 1 sq. ft. of horizontal cross-section for each 2,100 lb. of water per hour should be provided. When a stand pipe is used for air separation, one with a diameter equal to that of the pump cylinder is usually sufficient.

TABLE 12. CAPACITIES OF VARIOUS SIZES OF DIRECT DOUBLE ACTING STEAM-DRIVEN RECIPROCATING VACUUM PUMPS (FOR STEAM PRESSURE 50 LB. AND ABOVE)

SIZE, INCHES	SQUARE FEET OF DIRECT RADIATION
4 x 3 x 6	1,700
4 x 3⅝ x 6	2,500
4 x 4 x 6	3,000
4 x 4½ x 6	3,800
4 x 5 x 6	4,700
4 x 5 x 8	6,500
4½ x 6 x 8	10,000
5 x 6 x 10	11,000
5 x 6½ x 10	13,000
5 x 7¼ x 10	17,000
6 x 8 x 12	25,000
8 x 10 x 12	40,000
8 x 12 x 12	55,000
10 x 14 x 12	75,000
10 x 14 x 16	85,000
10 x 14 x 20	100,000
12 x 16 x 20	130,000
14 x 18 x 20	160,000
16 x 20 x 20	200,000
16 x 22 x 20	240,000

The freely vented air separating tank is preferable wherever a suitable location is available. The tank should be located at such a height that the pressure produced by the water column in its discharge pipe will be sufficient to overcome that in the low-pressure boiler feed-water heater or other point of disposal. Fig. 3 shows an arrangement which may be used for vacuum pump, air separating tank and feed-water heater. This arrangement provides means for the air to escape through a vent in the top of the tank and for the water to flow by gravity to the feed-water heater, through the loop seal attached to the discharge outlet of the tank. If the rate of flow of returns to the tank exceeds the rate of discharge from the tank the excess is permitted to overflow through an opening in the end of the tank, near the top.

The hydro-pneumatic type separating tank may be used whenever an open tank cannot be located at a height sufficient to provide gravity head to discharge the tank contents against the maximum pressure in the heater or boiler. A float-controlled valve is placed on the air outlet of the separating tank and so arranged that when the water of condensation has insufficient head to flow by gravity to the point of use, the air will be confined in the upper part of the tank. Its operation is such that when the pump continues to deliver water and air to the tank the pressure within the tank increases until it becomes sufficient to discharge the water, thus lowering the water line and eventually permitting escape of the surplus air through the float-controlled air valve. The confined air pressure in the tank plus the gravity head in the tank discharge pipe, must be sufficient to cause flow to the place of disposition. This confined air pressure, plus the column of mixed air and water in the pump discharge to the tank, constitute the total head against which the pump must act. Fig. 3 shows a hydro-pneumatic separating tank, as well as a freely-vented separating tank, for alternate use as conditions require.

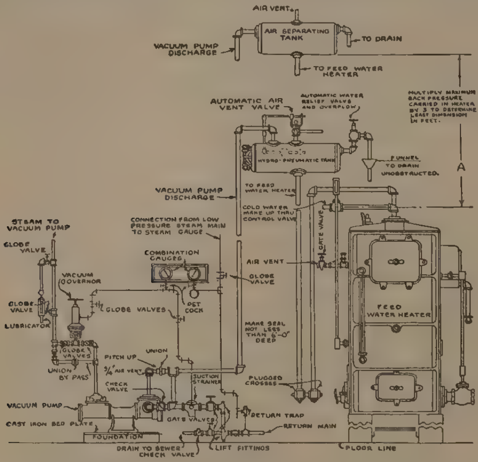


FIG. 3. METHOD OF CONNECTING VACUUM PUMP, FEED WATER HEATER AND SINGLE CONTROL HYDRO-PNEUMATIC TANK OR AIR SEPARATING TANK

Where the pressure in the heater, boiler, etc., varies materially from time to time and where it is desired to save energy by diminishing the head against which the pump shall work, a hydro-pneumatic type tank may be used, instead of a plain tank set at a higher elevation, to overcome the peak pressure in the boiler or heater.

Table 13 gives the size of plain and hydro-pneumatic tanks for air separating purposes and also those for storage of returns. In the latter case the tanks are based upon storing the quantities of water which will be discharged during five minutes at the basis of hourly rates given in the first column.

When the head on the delivery side of steam-driven vacuum return pumps exceeds 15 lb. per square inch the condensate should be delivered

TABLE 13. SIZES OF PLAIN AND HYDRO-PNEUMATIC SEPARATING TANKS

CONDENSATION POUNDS PER HOUR	FOR AIR SEPARATION ONLY		FOR AIR SEPARATION AND WATER STORAGE	
	Diameter Inches	Length Inches	Diameter Inches	Length Inches
4,000	12	24	24	36
6,000	12	36	24	48
8,000	18	30	24	72
10,000	18	48	30	48
16,000	24	48	30	60
24,000	30	48	36	60
......	24	72	36	72
34,000	36	60	36	96
......	36	72	42	72
45,000	42	60	42	96
......	36	96	..	..
60,000	42	72	48	72
......	42	96	48	96

to a vented receiver located close to the level of the vacuum pump outlet. This receiver should be connected to a separate steam or power driven water pump capable of delivering against the maximum head and should be controlled by a throttle valve or motor control, actuated by some suitable means, from the water line in the receiving tank.

Typical vacuum pump connections for several different conditions of service, are shown by Figs. 4, 5 and 6.

LIFTS

In vacuum heating systems where condensation is to be raised to a higher level it should be accomplished by means of lift fittings.

Lifts of 6 ft. or over should be made in steps rather than in one rise or through drag lift (consisting of long upwardly-inclined pipes.) In any case the pipes between the lifts should grade downward toward the pump.

SPECIFICATIONS FOR PUMPS

General.—Reciprocating and power driven pumps should be specified as to make, size, working water and steam pressures, piston speed, temperature of water to be handled, electric motor characteristics, and to insure economy in production, such standard practices as subsequently indicated.

The kind of drive should be specified for power-driven pumps.

Centrifugal and rotary pumps should be specified as to make, type, capacity, temperature of water to be handled, speed and motor characteristics, including the following:

(1) Name of motor manufacturer; (2) manufacturers rated horsepower; (3) the maximum temperature rise (deg. cent.) for any part of the motor above the temperature of the surrounding air; (4) full-speed in revolutions per minute; (5) current characteristics; (6) whether the motor is to be

open, semi-enclosed or fully enclosed; (7) kind of starting and control equipment, *i.e.*, open or enclosed panels, manual or automatic controls.

There should also be included in the specifications such items as total head to be pumped against, including suction lift, friction head, velocity head and head against which the pump must discharge. The vacuum under which return pumps are required to operate and whether two or more units are to operate in parallel or separately.

TYPES OF PUMPS

The following definitions of the types of pumps, which are in accordance with the *Hydraulic Societies' Standards*, should be used:

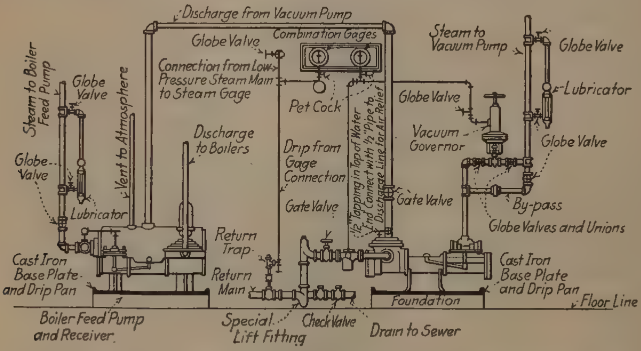


Fig. 4. Method of Connecting Vacuum Pump and Automatic Boiler-Feed Pump and Receiver

Direct Acting Steam Pump.—A steam-driven reciprocating pump in which the steam piston is directly connected to the liquid piston or plunger through the piston rod.

Crank and Flywheel Pump.—A steam-driven reciprocating pump with crankshaft on which a flywheel is mounted for storing energy during the early part of the stroke and imparting this stored energy to the liquid piston or plunger during the latter part of the stroke, after the steam is cut off in the steam cylinder. The length of the stroke is determined by the throw of the main crank.

Single Steam Pump.—A steam-driven reciprocating pump having one liquid piston or its equivalent single or double acting plunger.

Duplex Steam Pump.—A steam-driven reciprocating pump having two liquid pistons or their equivalent single or double acting plungers.

Power Pump.—A reciprocating pump driven by power from an outside source applied to the crankshaft of the pump.

Single Power Pump.—A power-driven reciprocating pump having one liquid piston or its equivalent single or double acting plunger.

Duplex Power Pump.—A power-driven reciprocating pump having two liquid pistons or their equivalent single or double acting plungers.

Triplex Power Pump.—A power-driven reciprocating pump having three pistons or their equivalent single or double acting plungers.

Single Stage.—A centrifugal pump having one impeller.

Multi-Stage.—A centrifugal pump having two or more impellers acting in series in one casing.

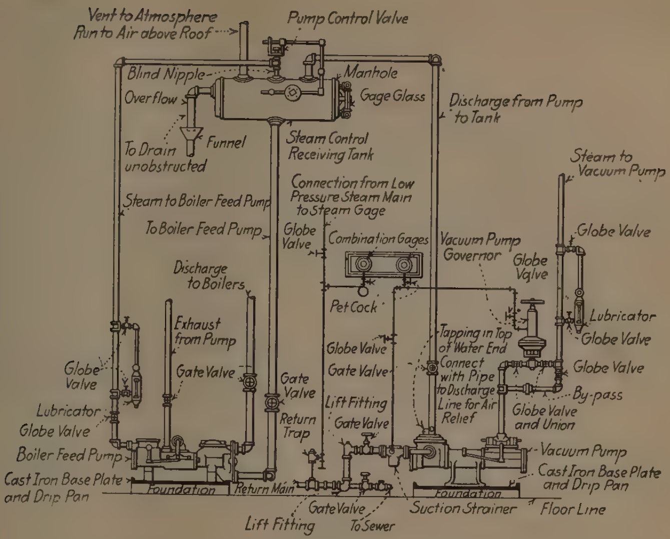


FIG. 5. METHOD OF CONNECTING VACUUM PUMP, BOILER-FEED PUMP AND STEAM-CONTROL RECEIVING TANK

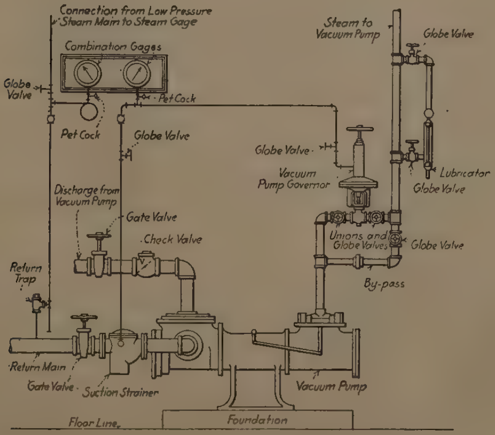


FIG. 6. METHOD OF MAKING CONNECTION TO STEAM-OPERATED VACUUM PUMP

Screw or Propeller Pump.—A centrifugal pump having a screw type impeller. May be axial flow or combined axial and radial flow type.

FITTINGS OF PUMPS

The following definitions of the fittings of pumps, which are in accordance with the *Hydraulic Societies' Standards*, should be used:

Standard Fitted Steam or Power Pumps (*Symbol S. F.*).—Steel piston rods; iron liquid pistons or plungers; bronze or rubber liquid valves; bronze liquid valve seats; guards and springs; liquid cylinders iron or steel. Piston pattern pumps have bronze lined liquid cylinders. Plunger pattern pumps, iron cylinders and plunger glands (not bushed); steel cylinders, and plunger glands (bronze bushed).

Bronze Fitted Steam or Power Pumps (*Symbol B.F.*).—Bronze piston rods (except end-packed plunger pattern) iron liquid pistons or plungers; bronze or rubber liquid valves; bronze liquid valve seats; guards and springs; liquid cylinders iron or steel; piston pattern pumps have bronze lined liquid cylinders; plunger pattern pumps have bronze bushed plunger glands and throats.

Full Bronze Fitted Steam or Power Pumps (*Symbol F. B. F.*).—Bronze piston rods (except end-packed plunger pattern) bronze liquid pistons or plungers; bronze or rubber liquid valves; bronze liquid valve seats; guards and springs. Liquid cylinders iron or steel. Piston pattern pumps have bronze lined liquid cylinders; plunger pattern pumps have bronze bushed plunger glands and throats.

Acid Resisting Pump (*Symbol A. R.*).—All parts of the pump in direct contact with the liquid pumped are to be constructed of such materials as will offer the maximum resistance to the corrosive action of the liquid.

All Bronze Pump (*Symbol A. B.*).—All parts of the pump coming in direct contact with the liquid pumped are to be made of bronze.

All Iron Pump (*Symbol A. I.*).—All parts of the pump coming in direct contact with the liquid pumped are to be made of iron or ferrous metal.

Standard Fitted Centrifugal Pumps (*Symbol S. F.*).—Casing of cast iron; shaft of steel; impeller of bronze or cast iron; wearing rings and shaft sleeves when used of bronze or cast iron.

Bronze Fitted Centrifugal Pumps (*Symbol B. F.*).—Casing of cast iron; shaft of steel; impeller of bronze; wearing rings and shaft sleeves when used, of bronze.

STANDARD EQUIPMENT OF PUMPS

The following lists of standard equipment, which are in accordance with the *Hydraulic Societies' Standards*, should be used:

Trade Steam Pumps (*Single or Duplex*).—The following is considered standard equipment for trade pumps and is to be furnished by the manufacturer:

Drip cocks for steam cylinders, Drain plugs for liquid cylinders, Special wrenches, Piston packing for *water* only, Oil or grease cups for rocker shafts, companion flanges for all openings up to 6 in. inclusive.

Plunger packing will be furnished for inside packed plunger pumps. Packing will not be furnished for outside packed plunger pumps.

Power Pumps.—The following is considered standard equipment for duplex and triplex power pumps:

Liquid Valve Service, Oil or Grease Cups, Tight pulley only, Discharge air chamber up to 400 lb. pressure. Companion flanges up to and including 6 in. Special wrenches where required.

Gear Guard covering the teeth of the pinion and the adjacent teeth of the gear will be furnished as a part of the Standard Equipment. *Gear Guards conforming to the laws of the various states will be furnished as extras, when such laws are quoted in the purchaser's inquiry or order.*

Centrifugal Pumps.—The following is considered standard equipment for horizontal centrifugal pumps:

Coupling or pulley, Bed plates up to 24 in. pumps inclusive, Oil gages for bearings. Air cock at top of pump casing. Drain plug at bottom of pump casing. Packing for shaft stuffing boxes. Water seal gland—piping for same optional. Special wrenches when required.

DEFINITIONS OF TERMS USED

The following definitions of terms, which are in accordance with the *Hydraulic Societies' Standards*, should be used:

Static Head is the vertical distance between the free level of the source of supply and to the point of free discharge, or to the level of the free surface of the discharge water.

Total dynamic head is the vertical distance between the source of supply and point of discharge when pumping required capacity, plus velocity head, plus friction, velocity, entrance and exit losses.

Total dynamic head as determined on test, where suction lift exists, is the reading of a mercury column connected to the suction nozzle of pump, plus the reading of a pressure gage connected to discharge nozzle of pump, plus vertical distance between point of attachment of mercury column and center of gage, plus excess, if any, of velocity head of discharge over velocity head of suction as measured at points where the instruments are attached, plus head of water resting on mercury column, if any.

Total dynamic head as determined on test, where suction head exists, is the reading of a gage attached to the discharge nozzle of pump minus the reading of gage connected to the suction nozzle of pump, plus or minus vertical distance between centers of gages (depending on whether suction gage is below or above discharge gage), plus excess, if any, of velocity head of discharge over velocity head of suction as measured at points where instruments are attached.

Total dynamic discharge head is the total dynamic head minus dynamic suction lift, or plus dynamic suction head.

Suction Lift.—Suction lift exists when the suction measured at the pump nozzle and corrected to the center line of the pump is below atmospheric pressure.

Static suction lift exists when the source of supply is below the center of pump and is the vertical distance from the free level of source of supply to center of pump.

Dynamic suction lift, where static suction lift exists, is the vertical distance from the source of supply, when pumping required capacity, to center of pump, plus velocity head, plus entrance friction and velocity losses, but not including internal pump losses, where static suction head exists but where the losses exceed the static suction head, the dynamic suction lift is the sum of the velocity head, entrance, friction and velocity losses, minus the static suction head, but not including internal pump losses.

Dynamic suction lift as determined on test, is the reading of a mercury column connected to suction nozzle of pump, plus vertical distance between point of attachment of mercury column to center of pump, plus head of water resting on mercury column, if any.

Suction Head (sometimes called head on suction) exists when the pressure measured at the suction nozzle and corrected to the center line of the pump is above atmospheric pressure.

Static suction head exists when the source of supply is above the center of pump and is the vertical distance from the free level of the source of supply to center of pump.

Dynamic suction head, where static suction head exists, is the vertical distance from the source of supply, when pumping at required capacity to center of pump, minus velocity head, minus entrance friction and velocity losses, but not minus internal pump losses.

Dynamic suction head as determined on test is the reading of a gage connected to suction nozzle of pump, minus vertical distance from center of gage to center line of pump. Suction head, after deducting the various losses, may be a negative quantity, in which case a condition equivalent to suction lift will prevail.

Guarantee on Suction Lift.—All guarantees, unless otherwise specified, should be based on handling clear fresh water at a temperature of not over 85 deg. fahr. and a total dynamic suction lift of not over 15 ft. at sea level.

HORSE POWER OF MOTORS

For motors of less than 100 hp. capacity when rated on a 50 deg. basis and when used to drive centrifugal pumps should be of a capacity at least 20 per cent above the actual horsepower required by the pump. When rated on a 40 deg. basis the extra margin of capacity should be made 5 per cent in excess of the actual power required by the pump at the normal rated capacity conditions for which the pump is guaranteed. For motors over 100 hp. capacity the rated motor capacity may be less than that given previously.

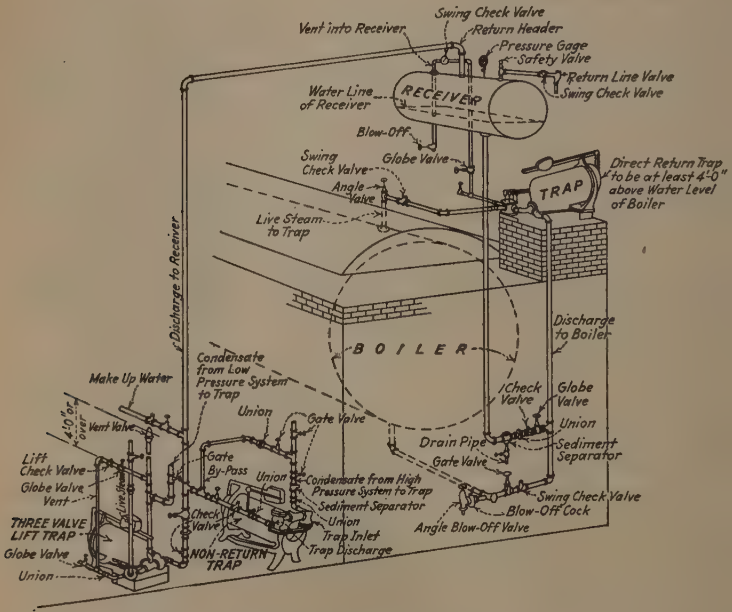


Fig. 7. Traps and Receiver for Returning Condensate from High and Low Pressure Systems to a Boiler

INSTALLATION DATA

All pumps, in general, should be set on substantial foundations and be provided with heavy cast iron sub-bases, securely anchored to foundation and provided with drip rim with drain connected to sump or sewer.

Especially in the case of centrifugal or turbine pumps every reasonable precaution should be taken to prevent distortion of base plates of pumps due to handling in shipment or bolting down without suitable grouting.

Flexible couplings should not be used to compensate for misalignment but only to compensate for temperature variations.

Pipe connections should, in general, be supported to prevent undue stresses in pumps due either to weight or expansion.

The exhaust from steam-driven pumps supplying steam for heating purposes should be taken through an effective oil separator before entering any part of the heating system or other apparatus.

A full set of the manufacturer's working drawings should be used in connection with each installation.

TRAPS

Traps ordinarily used in connection with heating and ventilating engineering may be divided into the following three types: (1) steam traps; (2) oil traps; (3) air traps.

Steam traps may be sub-divided into: (*a*) high-pressure steam traps; (*b*) low-pressure steam traps, and each of these two sub-divisions may be further sub-divided into: (1) float traps; (2) bucket traps; (3) thermostatic traps; (4) return traps; (5) lifting traps; (6) alternating receiver traps; (7) tilt traps.

The fundamental principle upon which the operation of practically all traps depend is that the pressure within the trap at the time of discharge, shall be equal to, or slightly in excess of, the pressure against which the trap must discharge, including the friction head, velocity head and static head on the discharge side of the trap. If the static head is in favor of the trap discharge it is a minus quantity and may be deducted from the other factors of the discharge head.

The capacity of a trap depends upon the clear area through its discharge ports and the difference between the pressure within the trap and the total pressure against its discharge, at the time of discharge.

The opening of the ports of a trap may be a very variable quantity, depending upon the action of the mechanism in opening and closing the valves.

Float traps and thermostatic traps generally have gradual opening and closing of valves, although some of these are arranged with levers, weights, springs, etc., so as to snap open and close, thus giving a full opening of the valves and ports during the entire time of each discharge.

Bucket traps, tilt traps and alternating receiver traps have quick-acting valves and therefore wide open ports during each discharge.

Uses of traps in connection with heating and ventilating apparatus are for draining the condensate from all kinds of radiators, heaters, steam piping systems, kitchen equipment, laundry equipment, hospital equipment, drying equipment and many other kinds of steam-heated apparatus. The usual function of a trap is to allow the passage of condensate and to prevent the passage of steam. In addition to these functions, traps are frequently required to allow the passage of air as well as condensate. Traps are also required to allow the passage of air and to prevent the passage of either water or steam, or both.

In addition, traps are used for returning condensate either by gravity, by steam pressure, or by both, to a boiler or other point of disposal. Also for lifting condensate from a lower to a higher elevation, or for handling condensate from a lower to a higher pressure.

By-passes are usually provided around traps with a valve and union on each side of the trap and one of each in the by-pass. Some traps are provided with integral by-passes for temporary relief in case of emergency but these do not allow the removal of the trap for repairs without interrupting the service.

High-pressure float, and alternating traps are usually provided with glass water gages, drain cocks and air-relief cocks or automatic air-relief valves.

Tilt traps are not ordinarily equipped with glass water gages as the action of the trap shows when it is filling or emptying.

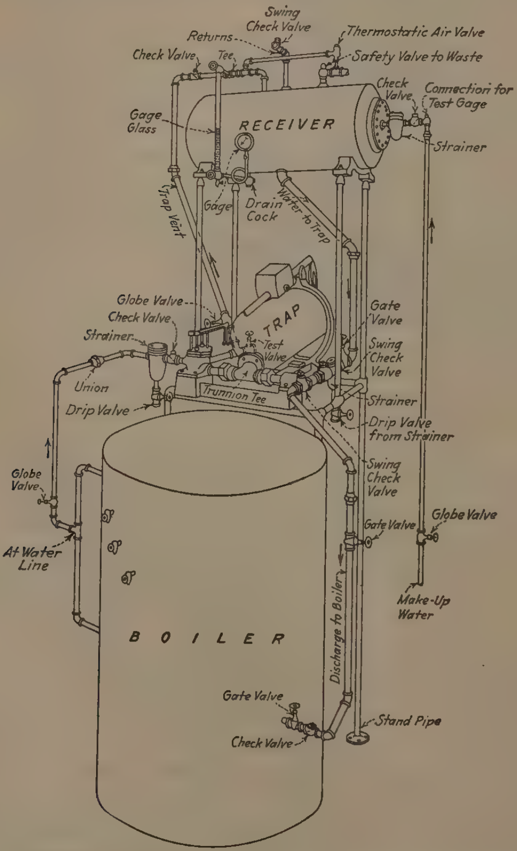


Fig. 8. Return Trap and Receiver for Automatic Boiler Feed

The air relief of tilt traps is taken care of by the valves of the trap. High-pressure traps for handling large volumes of condensate are usually of the float, bucket, tilt or alternating types, although some forms of thermostatic traps are designed for this kind of service. For smaller high-pressure apparatus many types of thermostatic traps are very efficacious. Care should be taken to see that thermostatic traps of the bellows or diaphram type, when used for high-pressure service are properly constructed with materials and solder that will properly withstand the maximum temperature of the steam.

Low-pressure traps of the various types are equipped substantially the same as high-pressure traps of similar types. Thermostatic traps are generally used for draining radiators and heaters, except for very large capacities where bucket, float or blast traps are used. Thermostatic traps for this service usually pass both condensate and air and in case of float and bucket traps the air is usually relieved through an auxiliary thermostatic trap in a by-pass around the main trap. Sometimes this auxiliary air trap is an integral part of the trap. Blast traps are sometimes used on a vacuum heating system for connecting old one or two pipe gravity systems in parallel with vacuum return line systems; in which case the blast traps should not be provided with auxiliary air by-pass, as the action of this will allow the vacuum to draw air into the old system through its air valves, especially when the steam is wholly or partially cut off. The air from the returns of such old systems should be relieved just ahead of the blast traps by means of quick venting automatic air valves, preferably of the non-return type, especially if the other air valves on the old system are non-return valves.

Lifting traps will discharge from a lower to a higher pressure and are usually of the tilt or alternating type. Either of the two former types of traps are provided with two or three valves, operated by the action of the trap.

In case of the two-valve traps, one valve closes a steam inlet and the other valve opens a vent outlet while the trap is filling and as soon as the trap dumps the first valve opens the steam inlet and the second valve closes the vent outlet, while the trap discharges. In this type of trap there must be a swinging-check valve on each side of the trap, in addition to the usual by-pass, to prevent the pressure in the trap, while discharging, from backing up through the inlet and the pressure in the discharge line from backing up into the trap while it is filling. This type of trap will blow steam out through the vent while filling, if the pressure on the inlet side is sufficient, and should not be used, therefore, with such pressures unless the vent is properly piped back into the return to a feed water heater, condenser or to a perforated pipe in the bottom of the receiver to which the trap discharges in such a way as to prevent the escape of the steam that comes in with the condensate and passes through the vent. In the three-valve traps of this type there is an extra valve for closing the discharge while the trap is filling.

Some tilting traps are designed for use without venting any steam but with automatic thermostatic air trap for venting the air. Some of these are equipped with automatic valves for introducing a water spray while the trap is filling, thus condensing the steam not only from the former discharge but from the intake and re-evaporation. Such may be used as vacuum traps for producing pressures below atmosphere on the system to which the trap is connected.

Fig. 7 shows a lifting trap, a receiver and a return trap connected for lifting condensate from a system of returns and returning same to a boiler. The venting and condensing arrangements referred to above are also shown.

Fig. 8 shows a direct return trap and receiver properly connected for automatically feeding a boiler from a system of returns delivering the condensate to the receiver.

Oil traps are used for draining the oil and condensate from oil separators, muffler tanks, etc., and are usually of the float type.

Air traps are used for relieving the air from steam heating systems, hot water heating systems, domestic hot water systems, etc. For steam heating systems where air and water are to be passed and steam retained they are of the thermostatic type. Where air is to be passed and steam and water retained they are of the combination thermostatic and float type. For water systems where air is to be passed and water retained they are of the float type.

Alternating receiver type traps are used for returning the condensate to boilers or for lifting condensate from a lower to a higher level. They are generally of the two-valve type with one valve in the steam supply and one valve in the vent. The action of the float opens the vent and closes the steam supply while the trap is filling by gravity and closes the vent and opens the steam supply while the trap is discharging. The steam from the vent may be connected back into the return system to the trap to prevent the waste of heat. This type of trap requires a swinging check on each side to prevent the backing up of the discharge from the return system while the trap is discharging or into the trap while it is filling. The air is vented from the system, either through the vent of the trap to the atmosphere, or where this vent is connected back into the returns the air is vented separately from the trap vent through a thermostatic air trap.

CHAPTER 20

PIPING FOR STEAM HEATING SYSTEMS

Description of Systems; Allowance for Various Conditions; Pipe Size Tables; Details of Connections.

THE methods of selecting pipe sizes for steam heating systems presented in this chapter have been developed through the cooperative efforts of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *Heating and Piping Contractors National Association.* As a result of the extensive research investigations, engineers, architects and heating contractors may now design piping systems with a degree of accuracy that was heretofore impossible.

DEFINITIONS

Equivalent radiation means the equivalent capacity of heat-emitting units in terms of the standard capacity of cast iron radiation. (240 B.t.u. per square foot).

Piping systems for steam heating are broadly classified as one-pipe, two-pipe, vapor and vacuum systems. With any of them the condensation may be returned to the boiler by gravity or by mechanical devices.

A few of the terms used in describing these systems are defined as follows:

Gravity systems shall be defined as those in which the water of condensation is returned to the boiler by gravity.

Vacuum return line systems shall be defined as those which operate with the pressure at or above atmospheric in the steam lines and radiators, and with a vacuum in the return lines.

Differential vacuum systems shall be defined as those which operate with a fixed differential between the radiation and the return line, and with steam supplied to the radiation at pressures below or above atmosphere.

Vapor systems shall be defined as two-pipe systems which are controlled to operate below 2 lb. gage and which employ radiator supply valves and traps for steam regulation and a boiler protective device for water line control.

Supply mains shall be defined as the pipes through which the steam flows from the boiler or source of supply to the run-outs and risers leading to the heat-emitting units.

Return mains shall be defined as the pipes which carry condensate from the return risers and heat-emitting units to the boiler return header or to the mechanical device which delivers the condensate to the boiler.

Dry returns shall be defined as those returns which are above the water line in the boiler or above an elevation at which the pressure in the boiler will support the return condensation. Dry returns may also be those returns which have protective devices for preventing water from backing up in them if excessive boiler pressure is generated.

Wet returns shall be defined as those returns which are below the level of the water line in the boiler or below an elevation at which the boiler will support the return condensation.

Down-feed or *overhead systems* shall be defined as those in which the supply mains are above the level of the heat-emitting units which they serve.

Up-feed systems shall be defined as those in which the supply mains are below the level of the heat-emitting units which they serve.

One-pipe systems shall be defined as those in which there is but one connection to each radiator which must answer for both supply and return.

Two-pipe systems shall be defined as those in which one pipe is used for the supply of steam to the radiator and another for the return of condensation.

One-pipe supply risers are those which carry steam upward to the radiator and which also carry the condensation from the radiator flowing in a direction opposite to the steam flow.

Down-feed one-pipe risers are those which carry steam and the condensation from the radiator, in the same direction.

Two-pipe supply risers are those which carry steam to the radiator but which do not carry the condensation from the radiator, the condensation returning through a separate return pipe or riser.

STEAM DISTRIBUTION

The piping for steam distribution will be divided into two classes: (1) transmission mains; (2) service piping.

Transmission mains are defined as those that convey steam for a considerable distance either through or between buildings such as in district heating plants. In this type the steam is usually generated and transmitted to the building under high pressure. The velocities of flow used in the transmission mains are limited by the available or allowable drop in pressure.

Service piping is defined as that which conveys the steam and condensate in the building, starting either at the boiler or other source of supply and comprising the mains, branches, risers, run outs and return piping. This part of the system usually is low pressure and the pipe sizes are larger than for the distributing piping, as the velocity of the steam is lower and the available or allowable drop in pressure is small. See Tables 9 to 16 for the service pipe sizes for various systems.

The principal factors upon which the determination of pipe sizes for steam heating depends, are:

1. The equivalent length of the run from the boiler, or source of steam supply, to the farthest heating unit.

2. The total pressure drop, which may be allowed, between the source of supply and the end of the return system.

3. The maximum velocity of steam allowable for quiet and dependable operation of the system.
4. Unusual conditions in the building to be heated.

Length of Run

The length of run must not only include the actual linear feet of straight pipe, but also the proper allowance for fittings, valves and other items which cause drop in pressure.

Pressure Drop

Theoretically there are several factors to be considered such as initial pressure and the pressure required at the end of the line, but it is most important that (1) the total pressure drop does not exceed the initial pressure of the system; (2) that the pressure drop is not so great as to cause high velocities and in the case of counter-flowing condensate to cause water hammer; (3) that there is a constant initial pressure; (4) that there is sufficient difference in level between the water line of the boiler and the lowest point of the steam main, dry return and heating units.

It is recommended that all systems be designed for low initial pressure and a reasonably small pressure drop. Such systems will operate under higher pressures without difficulty. When a system is designed for high pressure with a relatively large pressure drop and then operated at a low pressure, it is apt to be noisy and to have poor circulation.

It is recommended that the total pressure drop never exceed one-half of the initial pressure. This applies to cases where the condensate is flowing in the same direction as the steam, but in the case of counter-flowing condensate the capacities should not exceed those shown in Tables 5 and 6.

Maximum Velocity

The capacity of pipe of a given size in any part of a steam or vapor heating system depends upon the quantity of condensation present, as well as upon the available pressure drop in the pipe. Where no water is present or where a limited quantity flows by gravity in the same direction as the steam the available pressure drop only need be considered.

Where water and steam flow counter to each other the velocity of the steam must not exceed certain values above which disturbance between the counter-flowing steam and water may produce objectionable sounds, water hammer, or may retain water in some parts of the system until pressure goes off. The velocity at which such disturbance takes place depends upon the size of the pipe, its position (whether vertical or horizontal), its pitch and the quantity of water flowing counter to the steam.

Unusual Conditions

Under this heading are the character and class of the building, the periodicity of use, the temperature required and the time in which it is to be attained at the beginning of each period.

In public buildings, schools, offices, stores and such buildings (where the occupants are normally at rest), the building should be heated to or near its required temperature at all times. In places of assemblage such

TABLE 1. FLOW OF STEAM IN PIPES

P = loss in pressure in pounds.
d = inside diameter of pipe in inches.
L = length of pipe in feet.
D = weight of 1 cu. ft. of steam.
W = pounds of steam per hour.

$$W = 5220\sqrt{\frac{PDd^5}{\left(1+\frac{3.6}{d}\right)L}}$$

$$P = 0.0000000367\left(1+\frac{3.6}{d}\right)\frac{W^2L}{Dd^5}$$

PRESSURE LOSS IN OUNCES	COL. 1	PIPE SIZE		INTERNAL AREA OF PIPE SQ. INCHES	COL. 2	STEAM PRESS. BY GAGE	COL. 3	LENGTH OF PIPE IN FEET	COL. 4
	$5220\sqrt{\frac{P}{100}}$	Nominal	Actual Internal Diameter		$\sqrt{\frac{d^5}{1+\frac{3.6}{d}}}$		$\sqrt{\overline{D}}$		$\sqrt{\frac{100}{L}}$
0.25	65.28	1	1.049	0.864	0.536	−1.0[a]	0.187	20	2.240
0.50	92.28	1¼	1.380	1.496	1.178	−0.5[a]	0.190	40	1.580
1.00	130.5	1½	1.610	2.036	1.828	0.0	0.193	60	1.290
2	184.6	2	2.067	3.356	3.710	0.3	0.195	80	1.120
3	226.0	2½	2.469	4.788	6.109	1.3	0.201	100	1.000
4	261.0	3	3.068	7.393	11.183	2.3	0.207	120	0.912
5	291.8	3½	3.548	9.887	16.705	5.3	0.223	140	0.841
6	319.7	4	4.026	12.730	23.631	10.3	0.248	160	0.793
7	345.3	4½	4.506	15.947	32.134	15.3	0.270	180	0.741
8	369.1	5	5.047	20.006	43.719	20.3	0.290	200	0.710
10	412.7	6	6.065	28.886	71.762	30.3	0.326	250	0.632
12	452.0	7	7.023	38.743	106.278	40.3	0.358	300	0.578
14	488.3	8	7.981	50.027	149.382	50.3	0.388	350	0.538
16	522.0	9	8.941	62.786	201.833	60.3	0.415	400	0.500
20	583.6	10	10.020	78.854	272.592	75.3	0.452	450	0.477
24	639.3	12	12.000	113.098	437.503	100.3	0.507	500	0.447
28	690.5	14	13.250	137.880	566.693	125.3	0.557	600	0.407
32	738.2	16	15.250	182.655	816.872	150.3	0.603	700	0.378
40	825.4					175.3	0.645	800	0.354
48	904.1					200.3	0.685	900	0.333
80	1167.2							1000	0.316
160	1650.7							1200	0.289
320	2334.5							1500	0.258
480	2859.1							2000	0.224

Column 1 × 2 × 3 × 4 = lb. of steam per hour that will flow through a straight pipe for a given condition.

Example: 1 oz. drop — 2 in. pipe — 1.3 lb. press. — 100 ft. equivalent length:

130.5 × 3.710 × 0.201 × 1 = 97.2 lb. per hour.
97.2 × 4[b] = 388.8 sq. ft. equivalent radiation.

Table 1 does not allow for entrained water in low-pressure steam, condensation in covered pipe and roughness in commercial pipe as found in practice.

[a] Pounds per square inch gage = 2.04 in. Vacuum, Mercury Column.
[b] The factor 4 is the approximate equivalent in square feet of steam radiation of 1 lb. of steam per hour.

s churches, theaters and auditoriums little heat should be used, for as he occupants fill the building it becomes a case of ventilation instead of eating. In factories or other buildings the heat given off by machinery, ccupants and illumination and that absorbed by the contents of the uilding should be taken into account. In buildings that are intermittently heated the extra load due to heating up of a cold system within stated time must be considered in determining the pipe sizes.

GENERAL DATA ON PIPE SIZES

The rate of flow of dry steam or steam with a small amount of water lowing in the same direction is in accordance with the general laws of as flow and is a function of the length and diameter of the pipe, the lensity of the steam and the pressure drop through the pipe. This relaionship has been established by Babcock in the formula given at the op of Table 1. In columns 1, 2, 3 and 4 of this table, the numerical alues of the factors for different pressure losses, pipe diameters, steam lensities and lengths of pipe have been worked out in convenient form o that the steam flowing in any pipe may be calculated by multiplying ogether the proper factors in each column as shown in the example at he bottom of the table.

Table 2 is a basic table giving the theoretical capacities of pipe in quare feet of direct cast iron radiation (Based on ¼ lb. steam per hour er square foot) and the resulting velocity in feet per second for various ressure drops in ounces per 100 ft. length of pipe with an initial steam ressure of 1 lb. gage. This table was compiled from the values given n Table 1. In using Tables 1 or 2 the total pressure drop figured should ever equal or exceed the initial pressure.

Example: In a 3 in. pipe, what pressure drop is required in ounces per 00 ft. of length of pipe to supply steam to 2,014 sq. ft. of equivalent adiation? The initial steam pressure is 1 lb. gage.

Solution: In Table 2, column for 3 in. pipe, find that steam for 2,014 q. ft. of equivalent radiation will be supplied at 1 lb. initial pressure nd a pressure drop of 3 oz. per 100 ft. length of run.

Table 3 is to be used with Table 2 for calculating the capacity of a team pipe, for other initial pressures and lengths when the capacity is nown for 1 lb. pressure and 100 ft. length.

To determine the capacity of any pipe under initial pressure other han 1 lb., multiply the capacity given in Table 2 by the pressure factor n Column 2, Table 3, opposite the required pressure indicated in Column 1.

Example: What is the capacity of a 100 ft. 4 in. pipe with 2 lb. initial ressure and pressure drop of 1 oz.?

Solution: From Table 2, find 2,457, the capacity of the 4 in. pipe with lb. initial pressure and 1 oz. pressure drop. Multiplying 2,457 by 1.03 he constant found in Column 2 of Table 3 for 2 lb. initial pressure gives ,531 as the capacity of the 4 in. pipe with 2 lb. initial pressure and a ressure drop of 1 oz. per 100 ft. length.

To determine the capacity for any length other than 100 ft., multiply he capacity given in Table 2 by the length factor in Column *B*, Table 3, pposite the required length in Column *A*.

TABLE 2. PRESSURE LOSS, CAPACITY IN SQUARE FEET OF EQUIVALENT RADIATION AND VELOCITY RELATIONSHIP BASED ON TABLE 1, FOR VARIOUS PRESSURE DROPS WITH 1 LB. INITIAL STEAM PRESSURE

(NOTE.—No allowance for condensation in pipe—unusual friction—scale—corrosion or other factors.)

PRESSURE LOSS IN OUNCES PER 100 FT.	PIPE SIZE													
	1″		1¼″		1½″		2″		2½″		3″		3½″	
	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second
¼	28	7.5	61	9	95	11	193	14	318	17	581	21	869	23
½	39	12	87	15	134	17	273	21	449	24	822	30	1228	33
1	56	17	122	21	190	24	386	31	635	36	1163	42	1737	47
2	79	25	173	30	269	34	546	43	898	50	1645	60	2457	68
3	96	28	212	38	329	42	668	53	1100	62	2014	74	3009	84
4	111	35	245	43	380	49	771	62	1270	72	2326	85	3474	97
5	124	37	274	47	425	55	863	69	1421	80	2600	95	3884	109
6	136	40	300	52	466	59	945	77	1556	88	2848	105	4255	118
7	147	43	324	56	503	66	1020	83	1681	95	3077	113	4596	128
8	157	47	346	61	538	70	1091	89	1797	102	3289	122	4913	136
10	176	52	387	68	601	79	1220	99	2009	114	3677	135	5493	151
12	192	58	424	74	659	87	1336	109	2201	125	4028	148	6017	167
14	208	63	458	80	711	94	1443	118	2377	134	4351	164	6500	180
16	223	70	490	86	760	100	1543	126	2541	144	4651	175	6948	192
20	249	75	548	96	850	112	1806	148	2841	161	5200	196	7768	215
24	273	82	600	106	931	124	1890	154	3113	177	5697	215	8510	238

PRESSURE LOSS IN OUNCES PER 100 FT.	PIPE SIZE													
	4″		5″		6″		8″		10″		12″		16″	
	Sq Ft.	Velocity Ft per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second	Sq. Ft.	Velocity Ft. per Second
¼	1229	26	2273	29	3731	35	7766	42	14,172	48	22,746	52	42,470	62
½	1738	37	3214	41	5276	49	10,983	60	20,043	72	32,168	76	60,061	88
1	2457	52	4546	49	7462	70	15,533	86	28,345	100	45,492	108	84,940	125
2	3475	74	6429	84	10,553	94	21,967	112	40,085	140	64,336	152	121,012	180
3	4256	91	7874	104	12,924	121	26,904	144	49,094	172	78,795	184	147,120	220
4	4914	105	9092	121	14,924	139	31,066	164	56,689	192	90,985	212	169,879	252
5	5494	118	10,165	135	16,685	156	34,733	184	63,380	224	101,724	240	189,937	280
6	6019	128	11,135	148	18,278	168	38,048	204	69,430	244	111,433	264	208,059	308
7	6501	139	12,027	160	19,742	174	41,096	220	74,993	264	120,361	288	224,729	336
8	6950	148	12,858	172	21,105	196	43,934	234	80,171	284	128,672	304	240,245	356
10	7770	166	14,376	193	23,597	216	49,120	268	89,633	312	143,860	340	268,603	400
12	8512	182	15,748	212	25,849	232	53,808	288	98,188	344	157,590	372	294,236	436
14	9194	196	17,009	224	27,920	260	58,120	316	106,056	372	170,217	404	317,815	474
16	9829	211	18,184	234	29,848	276	62,132	340	113,378	394	181,969	428	339,758	508
20	10,989	235	20,331	260	33,371	316	69,466	380	126,768	444	203,448	480	379,861	568
24	12,038	249	22,270	280	36,556	332	76,096	412	138,859	484	222,866	520	416,117	624

Note 1.—Capacities based on ¼ lb. condensation per square foot equivalent radiation—steam and condensation flowing in same direction—actual diameter of standard pipe.

Note 2.—For capacity of pipe with a given pressure drop, in a length other than 100 ft., multiply the capacity in this table for the given pressure per 100 ft. drop by the factor for required length, Column *B*, Table 3.

Note 3.—For capacity with initial pressures other than 1 lb., multiply capacity given in this table by factor for the required initial pressure. Column 2, Table 3.

Note 4.—To determine pressure loss with a given capacity for other lengths of pipe than 100 ft., multiply pressure loss given in this table for the given capacity by the required length of pipe and divide by 100.

Note 5.—Extra length to be added to straight run of pipe, for various fittings and valves to determine equivalent length. (See Table 4.)

Note 6.—All pipe should be well reamed and free from constrictions. (See Tables 6, 7 and 8.)

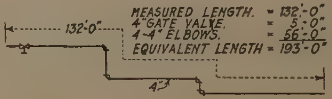
TABLE 3. CONSTANTS FOR VARIOUS LENGTHS AND INITIAL PRESSURES

STEAM PRESSURE GAGE LB.	CONSTANT BY WHICH TO MULTIPLY CAPACITY OF ANY PIPE FOR 1 LB. GAGE STEAM PRESSURE TO OBTAIN CAPACITY OF SAME PIPE FOR PRESSURE IN COL. 1	LENGTH OF PIPE FT.	CONSTANT BY WHICH TO MULTIPLY CAPACITY OF 100 FT. PIPE TO OBTAIN CAPACITY OF SAME SIZED PIPE WITH SAME PRESSURE, AND LENGTH AS GIVEN IN COL. *A*
Col. 1	Col. 2	Col. *A*	Col. *B*
0	0.92	20	2.240
1	1.00	40	1.580
2	1.03	60	1.290
5	1.11	80	1.120
10	1.24	100	1.000
15	1.35	120	0.912
20	1.45	140	0.841
30	1.63	160	0.793
40	1.79	180	0.741
50	1.94	200	0.710
60	2.08	250	0.632
75	2.26	300	0.578
100	2.54	350	0.538
125	2.79	400	0.500
150	3.02	450	0.477
175	3.23	500	0.447
200	3.44	600	0.407
...	....	700	0.378
...	....	800	0.354
...	....	900	0.333
...	....	1000	0.316
...	....	1400	0.267

TABLE 4. LENGTH IN FEET OF PIPE TO BE ADDED TO ACTUAL LENGTH OF RUN—DUE TO FITTINGS—TO OBTAIN EQUIVALENT LENGTH

SIZE OF PIPE INCHES	ST'D. ELBOW	SIDE OUTLET TEE	GATE VALVE	GLOBE VALVE	ANGLE VALVE
	Length in Feet to be Added in Run				
2	5	16	2	18	9
2½	7	20	3	25	12
3	10	26	3	33	16
3½	12	31	4	39	19
4	14	35	5	45	22
5	18	44	7	57	28
6	22	50	9	70	32
7	26	55	10	82	37
8	31	63	12	94	42
9	35	69	13	105	47
10	39	76	15	118	52
12	47	90	18	140	63
14	53	105	20	160	72

Example of length in feet of pipe to be added to actual length of run.



Example: What is the capacity of a 140 ft. 4 in. pipe with an initial pressure of 1 lb. and pressure drop of 2 oz. in the 140 ft.?

Solution: From Table 2 it is found that the capacity of a 100 ft. 4 in. pipe with 1 lb. initial pressure and 2 oz. pressure drop, is 3,475 sq. ft. Multiplying this value by 0.841 the constant for a 140 ft. length as given in Table 3 gives 2,922 the capacity for the given conditions.

Example: What is the capacity of a 140 ft. 4 in. pipe with 2 lb. initial pressure and a pressure drop of 2 oz.?

Solution: From Table 2 find 3,475, the capacity of the 4 in. pipe with 1 lb. initial pressure and 2 oz. pressure drop. Multiplying 3,475 by 1.03 the constant found in Column 2, Table 3, for 2 lb. initial pressure and this by 0.841 the constant found under Column *B*, Table 3, the constant for 140 ft. length all as given in Table 3 gives 3,010 as the capacity of the 4 in. pipe with 2 lb. initial pressure and a pressure drop of 2 oz. in the 140 ft. length.

Should lengths other than those given in Column *A*, Table 3, and under length of pipes in feet in Table 1 be desired the constant may be obtained, from the formula in Column 4, Table 1, and used the same as the constants from Table 3.

Example: What would be the constant for 2,500 ft. of pipe to be used either in Tables 1 or 3?

Solution: The $\sqrt{\frac{100}{2{,}500}} = 0.2$ or the constant to be used.

In determining the length of pipe used in any system, the actual length must be increased for the various fittings and valves, in determining the equivalent length before applying any of the tables given.

Gate valves are recommended in all cases where service calls for the valve to be either entirely closed or open. They should never be used for throttling. Angle and globe valves should be used for throttling, such as the by-pass valve in a pressure-reducing outfit.

Table 4 gives the allowance for fittings in feet of pipe to be added to the actual length of run to obtain the equivalent length.

SYSTEMS OF STEAM HEATING

The choice of gravity one-pipe, two-pipe, vapor or vacuum return line systems depends upon the requirements as to first cost, convenience, quality of service and local conditions. Theoretically, gravity one and two-pipe and vapor and vacuum return line systems are substantially on a par as to heating efficiency; that is to say, the major portion of the heat delivered is, or should be, dissipated by the heating unit.

It is essential that any system circulate steam uniformly throughout the entire installation, as too often certain defective features of a system will require that heat be kept on longer or to a greater degree than would otherwise be required uniformly and satisfactorily to heat the building. This will result in waste and overheating. The one important thing to be remembered in connection with all systems is that they shall circulate steam freely and uniformly to the heating units and shall remove and return the condensation noiselessly.

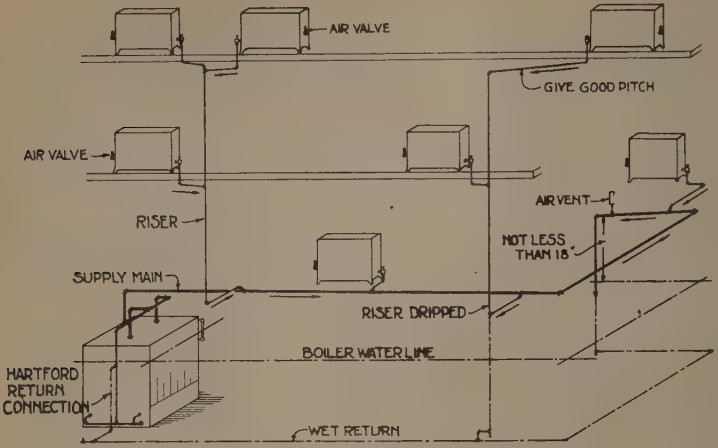


FIG. 1. TYPICAL GRAVITY ONE-PIPE STEAM SYSTEM

The following should be kept in mind in laying out any type of system:

1. The initial pressure should be kept as low as possible, not exceeding 5 lb. gage.

2. The drop in pressure in the mains and riser to the farthest heating unit should not exceed 1 oz. per 100 ft. of straight pipe or its equivalent length, with a lower rate of drop for systems with long runs.

3. In small installations, such as residences, where the longest actual run is seldom over 200 ft. and where the firing periods extend over several hours, resulting in boiler pressure, fluctuating from zero to about 1 lb., the total pressure drop should not exceed 2 oz. for gravity systems. In large buildings, where boilers are under the constant care of a fireman and a uniform pressure is maintained, and where the water-line difference will permit, the total drop in pressure may range from 3 to 8 oz., depending upon the equivalent length of the longest run.

4. The total allowable drop in pressure depends upon (*a*) the water-line difference, (*b*) the equivalent length of main and riser from the boiler to the farthest heating unit, and (*c*) the regularity of the pressure maintained at the boiler or source of steam supply.

5. The water-line difference, or distance between the water line of the boiler and the low point of steam main and dry return main should be not less than 24 in., because of the heavy drop in pressure from condensation in heating up a cold system. This difference should be increased 2 in. for every ounce pressure drop in the system. If the total pressure-drop were 6 oz., the water-line difference should be $6 \times 2 + 24$ or 36 in.

6. There should be a nearly uniform drop in pressure between the source of steam supply and the farthest heating unit on every riser. Care should be taken, however, to see that the maximum allowable velocity for smooth operation is not exceeded.

7. In using this method of proportioning a system, care must be exercised to see that no pipe carrying condensate counter to the steam is loaded to a capacity above the maximum for the particular part of a system in question.

While the pipe size tables given in this chapter, literally followed out, will doubtless serve as an efficient guide to the designer, it is impossible entirely to eliminate the factor of good engineering judgment. For example: While a given main might be calculated to begin at 5 in. and to end at 1½ in., better practice often would make it begin at 4 in. and end at 2½ in., since the dryer steam and higher velocity at the entry would compensate for smaller size at the end.

TABLE 5. MAXIMUM ALLOWABLE CAPACITIES OF UP-FEED RISERS FOR ONE-PIPE LOW PRESSURE STEAM

Based on A. S. H. V. E. Research Laboratory Tests

PIPE SIZE INCHES	VELOCITY FEET PER SECOND	PRESSURE DROP OUNCES PER 100 FT.	CAPACITY		
			Sq. Ft. Radiation	B.t.u. per Hour	Lb. Steam per Hour
A	*B*	*C*	*D*	*E*	*F*
1	14.1	0.68	45	10,961	11.3
1¼	17.6	0.66	98	23,765	24.5
1½	20.0	0.66	152	36,860	38.0
2	23.0	0.57	288	69,840	72.0
2½	26.0	0.54	464	112,520	116.0
3	29.0	0.48	799	193,600	199.8
3½	31.0	0.44	1144	277,000	286.0
4	32.0	0.39	1520	368,000	380.0

INSTRUCTIONS FOR USING TABLE 5

1. Capacities given in Table 5 should never be exceeded on one-pipe risers.
2. Capacities based on ¼ lb. condensation per square foot equivalent radiation and actual diameter of standard pipe.
3. All pipe should be well reamed and free from constrictions. Fittings should be up to size. (See Tables 7 and 8).

Gravity One-Pipe System

The gravity one-pipe system (Fig. 1) is considered by many engineers to be the simplest steam circulating system. It may be either of the atmospheric or of the vacuum type depending on whether or not vacuum-type or non-return air valves are used on radiators and return mains. If vacuum-type air valves are used the entire system must be tight and reasonably free from air leaks through supply valves, piping and boiler trimmings.

Each radiator has but a single pipe connection, through which steam must enter and through which the condensation also must return, flowing in the opposite direction to the steam flow. The main from the boiler should pitch downward from the highest point above the boiler, and at the end of this main it should drop down and be sealed independently below the boiler water line. This may be done at the remote end of the main or the main may loop back, above the boiler water line, to a point near the boiler, where it may be more convenient to seal it. Steam and condensation flow in the same direction in this supply main and the branches from the main are taken off the top.

The ends of the supply mains, before they are sealed below the water line, must be vented. Each radiator must have an air valve. Perfect grading of the mains and radiators so that no pools of water will lie in depressions in the pipes is imperative with this system, since these water pools always cause objectionable noise. Radiators with this system usually require that the supply valve be all-open or all-closed, since any intermediate valve-position is likely to cause interference with the necessary return of condensation.

It should be emphasized that in any part of a system in which water from the heating units returns counter to the steam the velocity of the steam must be kept below the point where it will seriously interfere with the returning water. The maximum allowable velocity of steam for satisfactory operation has been determined by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS Research Laboratory. Table 5 gives the maximum allowable capacity and velocities of flow for up-feed one-pipe risers while Table 6 gives the maximum capacity and velocity for horizontal pipes with various pitch.

Since the maximum velocity must not be exceeded in any part of the system, if silent and satisfactory operation are desired, care should be exercised to eliminate obstructions due to poor pipe, lack of or faulty reaming and improper use of pipe *dope*.

Tables 7 and 8 give the variation in capacity of pipe due to reaming and variation in size and smoothness of pipe as determined by experiments at the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS Research Laboratory. There are certain variations in manufacture which

TABLE 6. COMPARATIVE CAPACITY OF STEAM LINES AT VARIOUS PITCHES[a]

Pitch of Pipe in Inches per 10 Ft.

PITCH OF PIPE—¼ IN.			½ IN.		1 IN.		1½ IN.		2 IN.		3 IN.		4 IN.		5 IN.	
Pipe Size Inches	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.	Sq. Ft. Rad. Based on 240 B.t.u.	Max. Vel.
¾	25.0	12	30.3	14	37.3	18	40.4	19	42.5	20	46.1	21	47.5	22	49.3	23
1	45.8	12	52.6	15	63.0	17	70.0	20	75.2	22	83.0	23	87.9	25	90.2	26
1¼	104.9	18	117.2	20	133.0	23	144.5	25	154.0	27	165.0	28	172.6	29	178.2	31
1½	142.6	18	159.0	21	181.0	23	196.5	25	209.3	27	224.0	28	234.8	30	242.6	31
2	236.0	19	263.5	20	299.5	23	325.5	25	346.5	27	371.5	28	388.4	29	401.1	30

TABLE 7. EFFECT OF REAMING ENTRANCE TO ONE-PIPE RISERS[a]

	MAXIMUM CAPACITY OF RISER	PER CENT DECREASE
Reamed entrances	24.7 lb. per hour	0.0
Rounded entrances	23.9 lb. per hour	3.2
Squared entrances	22.2 lb. per hour	10.1
Three wheel cutter	19.2 lb. per hour	22.2
Single wheel cutter	17.6 lb. per hour	28.7

TABLE 8. PER CENT DIFFERENCE IN CAPACITY DUE TO VARIATION OF PIPE SIZE AND SMOOTHNESS[a]

	MAXIMUM CONDENSATION, LB. PER HR.			
Size of Pipe	¾″	1″	1¼″	1½″
Minimum	14.00	24.89	45.42	70.50
Maximum	15.20	30.08	52.08	82.00
Per Cent Variation	8.6	20.8	14.7	16.3

---

[a] Data from AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS Research Laboratory

apparently cannot be avoided, which actually caused a 20 per cent variation in the capacity of a 1 in. pipe, as indicated by Table 8. A factor of safety has been allowed in all of the capacity tables in this chapter so that Table 8, while interesting, need not be used to discount the other tables.

Table 9 is to be used in designing one-pipe systems up to 200 ft. equivalent length of run. For designing larger one-pipe systems where uniform distribution of steam to all parts of the building is difficult to obtain, Table 10 shall be used.

Gravity One-Pipe Down-feed System

The one-pipe gravity down-feed system illustrated in Fig. 2 is a modification of the one-pipe up-feed system and the same tables apply to it as for the up-feed system. The branches may leave the overhead main from the top, in which case the condensation drains at the end, or the branches may leave the overhead main from the bottom, in which case each branch drains the condensation, and in which case the installation of eccentric fittings in the overhead main may be avoided. The illustration indicates no drain at the base of the main supply riser. When this riser is more than very few feet from the boiler a connection from the bottom of the riser into the wet return should be made.

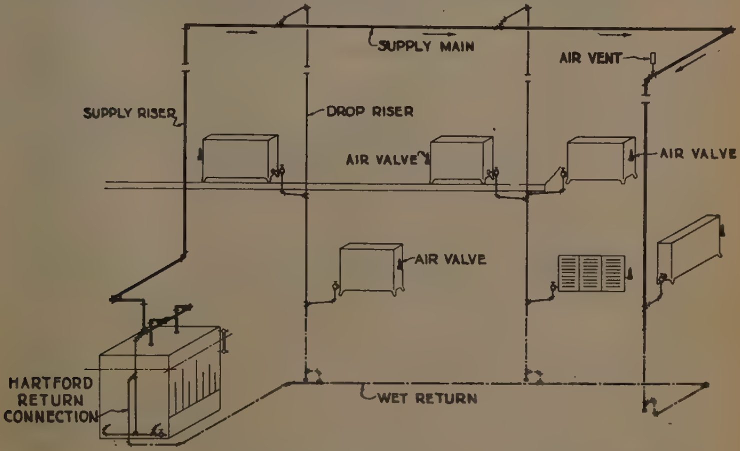


Fig. 2. Typical Gravity One-Pipe Down-feed Steam System

Gravity Two-Pipe System

Two-pipe systems, Fig. 3, require separate supply and return mains and a separate supply and return connection for each heating unit. Like one-pipe systems, they require air valves on heating units and mains. The connection may be either at the top or the bottom of the unit, but the outlet is always at the bottom so that all condensation will drain through this to the return mains instead of back through the inlet con-

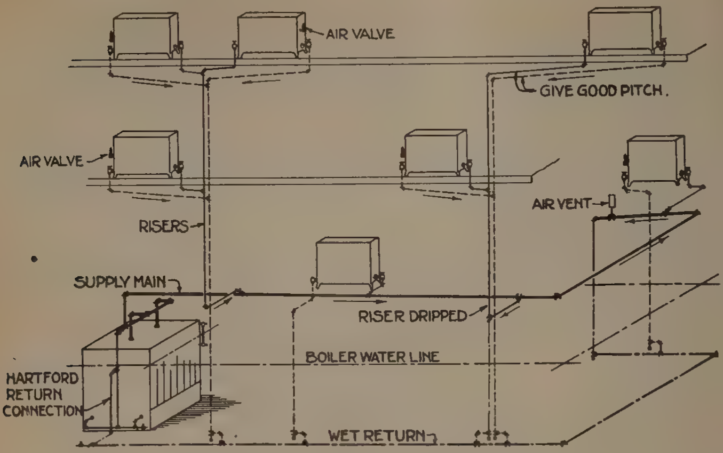


Fig. 3. Typical Gravity Two-Pipe Steam System

nection to the supply mains, as with the one-pipe system. Both radiator connections should be valved.

The returns from heating units on several floors are usually connected into common risers and the various risers tie into the return system.

This return system, if kept above the water line so as to remain dry, is

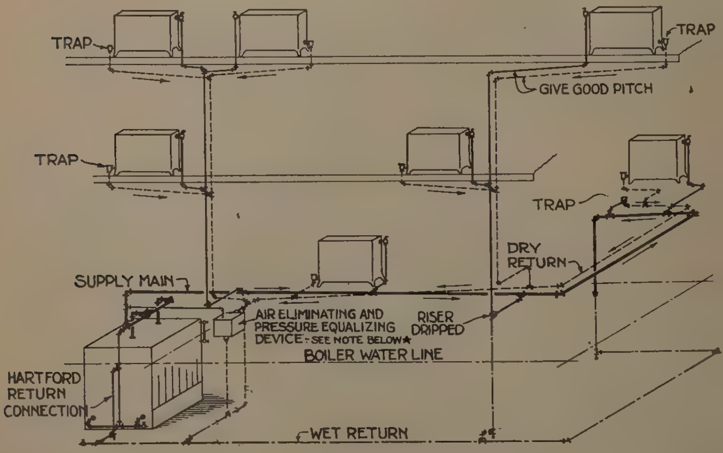


Fig. 4. Typical Gravity Vapor System

*Manufacturers of vapor specialties have special appliances for pressure equalizing and air elimination. Consult the manufacturer of such devices for proper piping connections, etc.

usually filled with steam (plus the water of condensation), at a pressure somewhere between that of the supply and that of the atmosphere, depending upon the amount of steam passing through the heating unit returns. This makes the gravity two-pipe system susceptible to the backing up of steam from one heating unit to another, if the return valve is left open, causing troubles due to water hammer, noise caused by counterflow and mixing of steam from the return, with the condensation leaving the heating units and air binding due to the premature closing of air valves by steam entering at the return end of the heating units. Sometimes check valves are used on the return end of heating units to prevent steam backing into those which have been shut off. This practice is not desirable as condensation may collect in the heating units, endangering the boiler. The troubles from the backing up of steam in the returns are generally eliminated when all heating unit returns are connected separately into the wet return. The return mains are kept below the water line, so as to be wet.

The two-pipe gravity steam system is almost obsolete, except for special installations. Old systems of this type may easily be changed to vapor systems by installing traps at the ends of the heating units and by arranging for dry returns with an air eliminator, or by using the old wet returns and installing a vacuum pump.

Gravity Vapor System

Fig. 4 illustrates a vapor system. The device at the end of the dry return main is usually of a proprietary nature. Its function is to vent the air and in some cases it prevents the reentry of air. Some of these devices are designed to maintain a constant differential between the pressure in the supply main and the pressure in the return main. A wet return main is not always essential, though in many cases it is a useful auxiliary.

Steam is prevented from entering the return main by thermostatic traps or other means of resistance on the return ends of the heating units and at drainage or venting points on the supply mains. There are no air valves, as such, on the heating units. With vapor systems the amount of vapor admitted to each heating unit is under throttle control at each supply valve. In addition some proprietary systems have a method of balancing steam flow by the use of an orifice with a fixed area proportioned in accordance with the size of each heating unit, while others use a supply valve which is of standard size and has an orifice that may be adjusted for each individual heating unit. In many of them the pressure in the supply main is under self-contained, automatic control.

Although in any type of two-pipe system the condensation from the heat-emitting units returns through separate piping, the condensation from radiator branches and risers must return through these pipes counter to the steam. The velocity of steam flow in such pipes must be kept below a certain maximum or this water will be held up until it accumulates in sufficient quantity to produce objectionable sounds and to interfere with proper circulation.

Table 11 gives the maximum capacity and velocity of steam for two-pipe risers as determined by the Research Laboratory.

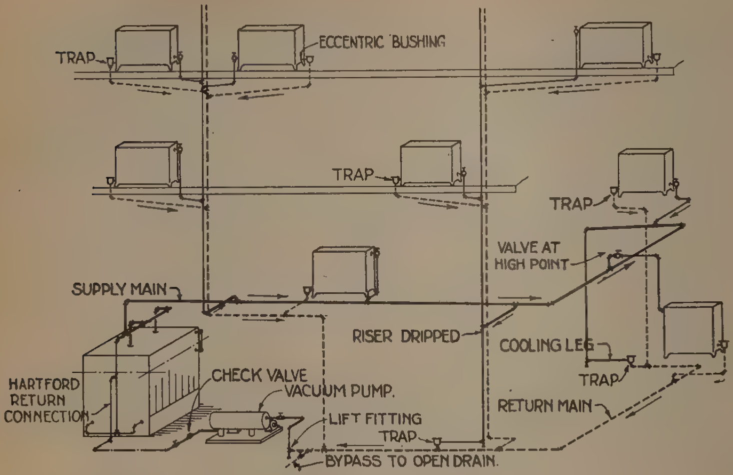


Fig. 5. Typical Installation Using Vacuum Pump

Table 12 is for comparatively small vapor systems. One ounce pressure drop may be understood to mean that the water in the vertical pipe which drains the end of the supply main will stand about 2 in. higher than the water line in the boiler, under normal conditions.

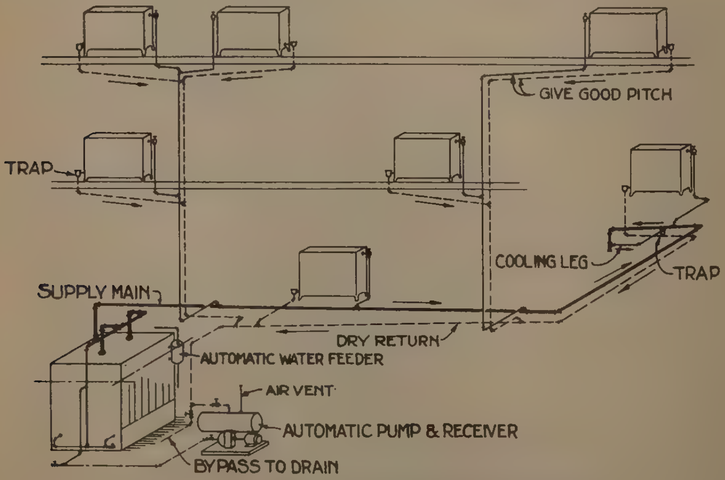


Fig. 6. Typical Installation Using Condensation Pump

Table 13 shows the pipe sizes for larger vapor systems than those in Table 12. Using these sizes, the water in the vertical pipe which drains the end of the supply main, will stand about 4 in. higher than the water line in the boiler under normal operation.

Table 14 shows the pipe sizes for vapor systems where a still greater difference in water line may be allowed between that in the boiler and in the return drop-pipe under normal operation. Where the basement

TABLE 9. PIPE SIZES FOR ONE-PIPE, GRAVITY, LOW PRESSURE STEAM HEATING SYSTEM, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO THE FARTHEST RADIATOR DOES NOT EXCEED 200 FT.

Capacity in Sq. Ft. of Equivalent Radiation

Based on Total Pressure Drop of 1 oz. per 100 ft.

PIPE SIZE INCHES	SUPPLY MAIN DRIPPED AND BRANCHES TO RISERS DRIPPED Steam and Condensate flowing in the same direction.	SUPPLY RISERS Up-Feed	BRANCHES TO SUPPLY RISERS AND RADIATORS NOT DRIPPED	WET RETURN MAIN	DRY RETURN MAIN	RADIATOR VALVE SIZES AND VERTICAL CONNECTIONS
A	*B*	*C*	*D*[1]	*E*	*F*	*G*
¾	------	25	------	------	------	------
1	56	45	20	700	320	20
1¼	122	98	55	1200	670	55
1½	190	152	81	1900	1058	81
2	386	288	165	4000	2300	165
2½	635	464	260	6700	3800	------
3	1163	799	475	10,700	7000	------
3½	1737	1144	745	------	10,000	------
4	2457	1520	1110	------	------	------
5	4546	------	2180	------	------	------
6	7462	------	------	------	------	------

Copyright, 1927 { AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS / *Heating and Piping Contractors National Association* } Not to be Reprinted Without Special Permission

INSTRUCTIONS FOR USING TABLE 9

1. Radiator branches more than 8 ft. in length should be one size larger than shown in Col. *D*.

2. These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (See Tables 7 and 8).

3. Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

4. Extra length to be added to straight run of pipe, for various fittings and valves to determine equivalent length. (See Table 4).

5. Where it is necessary to drip a steam main, branch to riser or risers, same should be dripped separately into wet return.

6. Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

7. In general it is desirable not to have a supply main smaller than 2 in. in diameter. When the supply main is larger than 2½ in. at the beginning, it is desirable that it shall not be smaller than 2½ in. at the end.

Table 10. Pipe Sizes for One-Pipe, Gravity, Low Pressure Steam Heating Systems, where Equivalent Length of Run from Boiler or Source of Supply to Farthest Radiator Exceeds 200 Ft.

Capacity in Sq. Ft. of Equivalent Radiation

Based on 4 oz. Total Pressure Drop

Pipe Size Inches	Equivalent Length of Pipe from Boiler to Farthest Radiator, Including Main and Riser. (See *Note 5.*) Supply Main Dripped and Branches to Risers Dripped — Steam and Condensate flowing in same direction.						Maximum Capacities		
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped	Radiator Valves and Vertical Connection
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*¹	*J*
1	111	79	65	56	49	46	**45**	20	20
1¼	245	173	141	122	110	100	**98**	55	55
1½	380	269	220	190	165	155	**152**	81	81
2	771	546	446	386	345	315	**288**	165	165
2½	1270	898	734	635	568	518	**464**	260	------
3	2326	1645	1342	1163	1040	948	**799**	475	------
3½	3474	2457	2006	1737	1552	1419	**1144**	745	------
4	4914	3475	2828	2457	2196	2011	**1520**	1110	------
5	9092	6429	5250	4546	4062	3712	-------	2180	------
6	14,924	10,553	8618	7462	6669	6094	-------	-------	------
8	31,066	21,967	17,935	15,533	13,880	12,682	-------	-------	------
10	56,689	40,085	32,730	28,345	25,334	23,144	-------	-------	------
12	90,985	64,336	52,530	45,492	40,660	37,145	-------	-------	------

Pipe Size Inches	Dry Return Main						Wet Return Main					
	Equivalent Length of Run from Boiler to Foot of Farthest Riser in Feet						Equivalent Length of Run from Boiler to Foot of Farthest Riser in Feet					
	100	200	300	400	500	600	100	200	300	400	500	600
K	*L*	*M*	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*	*V*	*W*
1	460	412	368	320	275	227	1400	1000	820	700	640	58
1¼	962	868	770	670	579	480	2400	1700	1390	1200	1080	99
1½	1512	1362	1210	1058	909	757	3800	2700	2180	1900	1710	157
2	3300	2960	2640	2300	1980	1630	8000	5600	4520	4000	3560	324
2½	5450	4900	4380	3800	3300	2770	13,400	9400	7600	6700	6000	530
3	10,000	9000	8000	7000	6000	5000	21,400	15,000	12,500	10,700	9400	850
3½	14,300	12,900	11,500	10,000	8600	7200	32,000	22,000	18,500	16,000	14,400	13,20
4	21,500	19,300	17,200	15,000	12,900	10,700	44,000	31,000	25,500	22,000	19,900	18,30

Copyright, 1927 { American Society of Heating and Ventilating Engineers *Healing and Piping Contractors National Association* } **Not to be Reprinted Without Special Permission**

INSTRUCTIONS FOR USING TABLE 10

1. Radiator branches more than 8 ft. in length should be one size larger than shown in Column *I*.

2. These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 7 and 8).

3. Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

4. Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 4).

INSTRUCTIONS FOR USING TABLE 10 (Continued)

5. Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in corresponding Columns (*B* to *G*) for supply mains; (*L* to *Q*) for dry-return mains; (*R* to *W*) for wet-return mains for sizing the entire run.

For example: If the distance from boiler or source of supply to the farthest radiator on the longest main should be 300 ft., all mains are to be sized from Column *D*; if 400 ft., Column *E;* if 600 ft., Column *G*.

Risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each particular riser.

Determine the distance to the farthest radiator then use the figures in the corresponding Columns (*B* to *G*) for sizing each riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *H*. Where riser capacities are found to be in excess of amounts in Column *H*, step up to necessary size indicated in that column.

For example: If the distance from the boiler or source of supply to the farthest radiator on a supply riser is 300 ft., that riser is to be sized from Column *D*, providing the amount of radiation does not exceed the amount shown in Column *H*. If the amount exceeds that in Column *H*, use amounts shown in Column *H* for sizing that entire riser.

If another riser taken from the same main as the one above is only 200 ft., this riser should be sized from Column *C*, providing the amount of radiation does not exceed that as shown in Column *H*.

6. The Guide Committee, 1930, after many check-tests, suggest that for practical purposes the pipe sizes on the usual heating system may be determined by using the pressure drop indicated by the longest main and riser on that system, neglecting the separate computations for each separate shorter run.

7. Where it is necessary to drip a steam main, branch to riser or risers, same should be dripped separately into wet return.

8. Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

9. In general it is desirable not to have a supply main smaller than 2 in. in diameter. When the supply main is larger than 2½ in. at the beginning, it is desirable that it shall not be smaller than 2½ in. at the end.

is high and where all heaters are well above the water line, and where they do not have unusual condensing power, these sizes are permissible. The difference here is 4 oz., or approximately 8 in.

Vacuum Pump Systems

Fig. 5 shows a typical vacuum system of steam heating, using a pump which handles both the air from the system and the water of condensation from it. With such arrangements a wide difference in pressure between that in the supply main and that in the return main is permissible. A greater temperature range within the system than that obtainable with vapor systems is insured. Heaters may be below the water line of the boiler, and even may be lower than the level of the pump, though such an arrangement generally should be avoided.

Table 15 gives approved pipe sizes for vacuum pump systems of comparatively small size, with a pressure drop not exceeding 4 oz., or a rise in the return connection of about 8 in., which, of course, easily can be overcome by the vacuum pump.

Table 16 gives pipe sizes for larger systems in which the vacuum pump is expected to maintain a greater suction, the allowable rise in the return connection being about 16 in.

It may be desirable in some cases to utilize a condensation pump rather than a vacuum pump where the heaters are too close to, or must be below, the boiler water line. Fig. 6 illustrates an approved hook-up for such a condition though, of course, the apparatus may be used with a wet return as well as with the dry return shown. It will be noted that each heater has a trap.

When a condensation pump is used with a one-pipe system a false water line should be established so that the sealing of each dry return against the others, so important with one-pipe systems, shall be maintained. Sometimes, in this contingency, it is desirable to place a float trap on the end of each separate dry return connection to the pipe which supplies the pump-suction.

There are a number of meritorious proprietary types of steam, vacuum return line, differential, and vapor heating systems, which vary in certain particulars from the foregoing typical examples. These systems have been developed to meet the requirements of the newer architecture of modern building construction and are based on well established engineering principles of control for occupancy, wind and sun effect, zone demands, etc. Descriptions of these systems will be found in the catalog section of The Guide.

TABLE 11. MAXIMUM ALLOWABLE CAPACITIES OF UP-FEED RISERS FOR TWO-PIPE LOW PRESSURE STEAM

Based on A. S. H. V. E. Research Laboratory Tests

Pipe Size Inches	Velocity Feet per Second	Pressure Drop Ounces per 100 Ft.	Capacity		
			Sq. Ft. Radiation	B.t.u. per Hour	Lb. Steam per Hour
A	*B*	*C*	*D*	*E*	*F*
¾	20	-----	40	9550	10.0
1	23	1.78	74	17,900	18.45
1¼	27	1.57	151	36,500	37.65
1½	30	1.48	228	55,200	57.0
2	35	1.33	438	106,100	109.5
2½	38	1.16	678	164,100	169.4
3	41	0.95	1129	273,500	282.2
3½	42	0.81	1548	375,500	387.0
4	43	0.71	2042	495,000	510.5

INSTRUCTIONS FOR USING TABLE 11

1. The capacities given in this table should never be exceeded on two-pipe risers.

2. Capacities based on ¼ lb. condensation per square foot equivalent radiation and actual diameter of standard pipe.

3. All pipe should be well reamed and free from constrictions. Fittings should be up to size. (See Tables 7 and 8).

TABLE 12. PIPE SIZES FOR TWO-PIPE, GRAVITY, VAPOR[b] SYSTEMS, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO FARTHEST RADIATOR DOES NOT EXCEED 200 FT.

Capacity in Sq. Ft. of Equivalent Radiation

Based on Total Pressure Drop of 1 oz. per 100 ft.

PIPE SIZE INCHES	SUPPLY MAIN DRIPPED AND B[redacted] TO RISERS DRIPPED Steam and Condensate flowing in same direction.	SUPPLY RISERS Up-Feed	BRANCHES TO SUPPLY RISERS AND RADIATORS NOT DRIPPED	RETURN RISERS	WET RETURN MAIN	DRY RETURN MAIN
A	*B*	*C*	*D*[1]	*E*	*F*	*G*
¾	----	30	----	190	------	------
1	56	56	26	450	700	320
1¼	122	122	58	990	1200	670
1½	190	190	95	1500	1900	1058
2	386	386	195	3000	4000	2300
2½	635	635	395	--------	6700	3800
3	1163	1129	700	--------	10,700	7000
3½	1737	1548	1150	--------	-----------	10,000
4	2457	2042	1700	--------	-----------	-----------
5	4546	--------	3150	--------	-----------	-----------
6	7462	**Different makes of supply and return valves, steam traps and other specialties vary as to capacity, therefore use size as recommended for any particular make. Vertical connections to be of same size as valve and trap used. Return horizontal runout to be not less than ¾ in.**				

Copyright, 1927 { AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS *Heating and Piping Contractors National Association* } **Not to be Reprinted Without Special Permission**

INSTRUCTIONS FOR USING TABLE 12

1. Radiator branches more than 8 ft. in length should be one size larger than shown n Column *D*.

[b]2. This table is for systems which are open to atmosphere or operate under slight pressure or partial vacuum without use of vacuum pumps.

3. These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 7 and 8).

4. Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

5. Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 4).

6. Where it is necessary to drip a supply main, supply riser or branch to a supply riser, same should be dripped separately into a wet return. The drip for a vapor or vacuum system may be taken into a dry return through a steam trap.

7. Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

8. In general it is desirable not to have a supply main smaller than 2 in. in diameter. When the supply main is larger than 2½ in. at the beginning, it is desirable that it shall not be smaller than 2½ in. at the end.

TABLE 13. PIPE SIZES FOR TWO-PIPE VAPOR HEATING SYSTEMS, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO FARTHEST RADIATOR **Exceeds** 200 FT.

Capacity in Sq. Ft. Equivalent Radiation

Based on 2 oz. Total Pressure Drop

PIPE SIZE INCHES	EQUIVALENT LENGTH OF PIPE FROM BOILER TO FARTHEST RADIATOR, INCLUDING MAIN AND RISER. (See *Note 6.*) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction.				MAXIMUM CAPACITIES		
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped	Return Risers
A	*B*	*C*	*D*	*E*	*F*	G^1	*H*
¾	----	----	----	----	**30**	----	190
1	79	56	46	39	**56**	26	450
1¼	173	122	100	87	**122**	58	990
1½	269	190	155	134	**190**	95	1500
2	546	386	315	273	**386**	195	3000
2½	898	635	518	449	**635**	395	------
3	1645	1163	948	822	**1129**	700	--------
3½	2457	1737	1419	1228	**1548**	1150	--------
4	3475	2457	2011	1738	**2042**	1700	--------
5	6929	4546	3712	3214	--------	3150	--------
6	10,553	7462	6094	5276	**Different makes of supply and return valves, steam traps and other specialties vary as to capacity, therefore use size as recommended for any particular make. Vertical connections to be of same size as valve and trap used. Return horizontal runout to be not less than ¾ in.**		
8	21,967	15,533	12,682	10,983			
10	40,085	23,345	23,144	20,043			
12	64,336	45,492	37,145	32,168			

PIPE SIZE INCHES	DRY RETURN MAIN				WET RETURN MAIN			
	EQUIVALENT LENGTH OF RUN FROM BOILER TO FARTHEST RADIATOR IN FEET				EQUIVALENT LENGTH OF RUN FROM BOILER TO FARTHEST RADIATOR IN FEET			
	100	200	300	400	100	200	300	400
I	*J*	*K*	*L*	*M*	*N*	*O*	*P*	*Q*
1	355	320	285	248	1000	700	580	500
1¼	745	670	595	520	1700	1200	990	850
1½	1173	1058	943	822	2700	1900	1570	1350
2	2680	2300	2140	1880	5600	4000	3240	2800
2½	4300	3800	3470	3040	9400	6700	5300	4700
3	7800	7000	6250	5480	15,000	10,700	8500	7500
3½	11,100	10,000	8800	7880	22,000	16,000	13,200	11,000
4	16,700	15,000	13,400	11,700	31,000	22,000	18,300	15,500

Copyright, 1927 { AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS *Heating and Piping Contractors National Association* } **Not to be Reprinted Without Special Permission**

INSTRUCTIONS FOR USING TABLE 13

1. Radiator branches more than 8 ft. in length should be one size larger than shown in Column *G*.

2. This table is for systems which are open to atmosphere or operate under slight pressure or partial vacuum without use of vacuum pumps.

3. These tables apply where pipes are properly reamed. No allowances for defective material of workmanship have been made. (Also see Tables 7 and 8).

4. Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

5. Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 4).

6. Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in corresponding Columns (*B* to *E*) for supply mains; (*J* to *M*) for dry-return mains; (*N* to *Q*) for wet-return mains for sizing the entire run.

For example: If the distance from boiler or source of supply to the farthest radiator on the longest main should be 300 ft., all mains are to be sized from Column *D;* if 400 ft., Column *E*.

Supply and return risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each riser.

For supply risers determine the distance from the boiler to the farthest radiator served by that riser then use the figures in the corresponding Columns (*B* to *E*) for sizing each supply riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *F*. Where supply riser capacities are found to be in excess of amounts shown in Column *F*, step up to necessary size indicated in that column.

For example: If the distance from the boiler or source of supply to the farthest radiator on a supply riser is 300 ft., that riser is to be sized from Column *D*, providing the amount of radiation does not exceed the amount shown in Column *F*. If the amount exceeds that in Column *F*, use amounts shown in Column *F* for sizing that entire riser.

If another riser taken from the same main as the one indicated is only 200 ft., this riser should be sized from Column *C* providing the amount of radiation does not exceed that as shown in Column *F*.

For return risers determine the equivalent length of run in feet from the top of each riser to the boiler, then use the figures in the corresponding Columns (*J* to *M*) for sizing each riser.

7. The Guide Committee, 1930, after many check-tests, suggest that for practical purposes the pipe sizes on the usual heating system may be determined by using the pressure drop indicated by the longest main riser on that system, neglecting the separate computations for each separate shorter run.

8. Where it is necessary to drip a supply main or a supply riser or a branch to a supply riser, same should drip separately into a wet return. The drip for a vapor or vacuum system may be taken into a dry return through a steam trap.

9. Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

10 In general it is desirable not to have a supply main smaller than 2 in. in diameter. When the supply main is larger than 2½ in. at the beginning, it is desirable that it shall not be smaller than 2½ in. at the end.

TABLE 14. PIPE SIZES FOR TWO-PIPE VAPOR HEATING SYSTEMS, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO FARTHEST RADIATOR **Exceeds** 200 FT.

Capacity in Sq. Ft. of Equivalent Radiation

Based on 4 oz. Total Pressure Drop

PIPE SIZE INCHES	EQUIVALENT LENGTH OF PIPE FROM BOILER TO FARTHEST RADIATOR, INCLUDING MAIN AND RISER. (See *Note 6*.) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction.						MAXIMUM CAPACITIES		
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped	Return Risers
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*[1]	*J*
¾	------	----	----	----	----	----	**30**	----	190
1	111	79	65	56	49	46	**56**	26	450
1¼	245	173	141	122	110	100	**122**	58	990
1½	380	269	220	190	165	155	**190**	95	1500
2	771	546	446	386	345	315	**386**	195	3000
2½	1270	898	734	635	568	518	**635**	395	--------
3	2326	1645	1342	1163	1040	948	**1129**	700	--------
3½	3474	2457	2006	1737	1552	1419	**1548**	1150	--------
4	4914	3475	2828	2457	2196	2011	**2042**	1700	--------
5	9092	6429	5250	4546	4062	3712	--------	3150	--------
6	14,924	10,553	8618	7462	6669	6094			
8	31,066	21,967	17,935	15,533	13,880	12,682			
10	56,689	40,085	32,730	28,345	25,334	23,144			
12	90,985	64,336	52,530	45,492	40,660	37,145			

Different makes of supply and retu valves, steam traps and other specialti vary as to capacity, therefore use size recommended for any particular mak Vertical connections to be of same si as valve and trap used. Return hor zontal runout to be not less than ¾ i

PIPE SIZE INCHES	DRY RETURN MAIN						WET RETURN MAIN					
	EQUIVALENT LENGTH OF RUN FROM BOILER TO FARTHEST RADIATOR IN FEET						EQUIVALENT LENGTH OF RUN FROM BOILER TO FARTHEST RADIATOR IN FEET					
	100	200	300	400	500	600	100	200	300	400	500	600
K	*L*	*M*	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*	*V*	*W*
1	460	412	368	320	275	227	1400	1000	820	700	590	48
1¼	962	868	770	670	579	480	2400	1700	1420	1200	1020	86
1½	1512	1362	1210	1058	909	757	3800	2700	2260	1900	1560	130
2	3300	2960	2640	2300	1980	1630	8000	5600	4500	4000	3360	280
2½	5450	4900	4380	3800	3300	2770	13,400	9400	7600	6700	5700	480
3	10,000	9000	8000	7000	6000	5000	21,400	15,000	12,300	10,700	9300	780
3½	14,300	12,900	11,500	10,000	8600	7200	32,000	22,000	24,000	16,000	13,600	11,40
4	21,500	19,300	17,200	15,000	12,900	10,700	44,000	31,000	26,000	22,000	20,500	15,40

Copyright, 1927 { AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS *Heating and Piping Contractors National Association* } **Not to be Reprinted Without Special Permission**

INSTRUCTIONS FOR USING TABLE 14

1. Radiator branches more than 8 ft. in length should be one size larger than shown in Column *I*.

2. This table is for systems which are open to atmosphere or operate under slight pressure or partial vacuum without use of vacuum pumps.

3. These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 7 and 8).

4. Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

5. Extra length to be added to straight run of pipe for various fittings and valves to determine equivalent length. (See Table 4).

6. Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in corresponding Columns (*B* to *G*) for supply mains; (*L* to *Q*) for dry-return mains; (*R* to *W*) for wet-return mains for sizing the entire run.

For example: If the distance from boiler or source of supply to the farthest radiator on the longest main should be 300 ft., all mains are to be sized from Column *D;* if 400 ft., Column *E;* if 600 ft. Column *G*.

Supply and return risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each riser.

For supply risers determine the distance from the boiler to the farthest radiator served by that riser then use the figures in the corresponding Columns (*B* to *G*) for sizing each supply riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *H*. Where supply riser capacities are found to be in excess of amounts shown in Column *H*, step up to necessary size indicated in that column.

For example: If the distance from the boiler or source of supply to the farthest radiator on a supply riser is 300 ft., that riser is to be sized from Column *D*, providing the amount of radiation does not exceed the amount shown in Column *H*. If the amount exceeds that in Column *H*, use amounts shown in Column *H* for sizing that entire riser.

If another riser taken from the same main as the one indicated is only 200 ft., this riser should be sized from Column *C*, providing the amount of radiation does not exceed that as shown in Column *H*.

For return risers determine the equivalent length of run in feet from the top of each riser to the boiler then use the figures in the corresponding Columns (*L* to *Q*) for sizing each riser.

For example: If the distance from the boiler or source of supply to the farthest radiator on a return riser is 300 ft., that riser is to be sized from Column *N*, providing the amount of radiation does not exceed the amount shown in Column *J*. If the amount exceeds that in Column *J*, use amounts shown in Column *J* for sizing that entire return riser.

7. The Guide Committee, 1930, after many check-tests, suggest that for practical purposes the pipe sizes on the usual heating system may be determined by using the pressure drop indicated by the longest main and riser on that system, neglecting the separate computations for each separate shorter run.

8. Where it is necessary to drip a supply main or a supply riser or a branch to a supply riser, same should drip separately into a wet return. The drip for a vapor or a vacuum system may be taken into a dry return through a steam trap.

9. Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

10. In general it is desirable not to have a supply main smaller than 2 in. in diameter. When the supply main is larger than 2½ in. at the beginning, it is desirable that it shall not be smaller than 2½ in. at the end.

TABLE 15. PIPE SIZES FOR VACUUM PUMP SYSTEMS, WHERE EQUIVALENT LENGTH OF RUN FRO BOILER OR SOURCE OF SUPPLY TO FARTHEST RADIATOR Exceeds 200 FT.

Capacity in Sq. Ft. of Equivalent Radiation

Based on 4 oz. Total Pressure Drop

PIPE SIZE INCHES	EQUIVALENT LENGTH OF PIPE FROM BOILER TO FARTHEST RADIATOR, INCLUDING MAIN AND RISER. (See *Note 6*.) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction.						MAXIMUM CAPACITIES	
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*[1]
¾	----	----	----	----	----	----	----	----
1	111	79	65	56	49	46	**56**	26
1¼	245	173	141	122	110	100	**122**	58
1½	380	269	220	190	165	155	**190**	95
2	771	546	446	386	345	315	**386**	195
2½	1270	898	734	635	568	518	**635**	395
3	2326	1645	1342	1163	1040	948	**1129**	700
3½	3474	2457	2006	1737	1552	1419	**1548**	1150
4	4914	3475	2828	2457	2196	2011	**2042**	1700
5	9092	6429	5250	4546	4062	3712		3150
6	14,924	10,553	8618	7462	6669	6094	--------	--------
8	31,066	21,967	17,935	15,533	13,880	12,682	--------	--------
10	56,689	40,085	32,730	28,345	25,334	23,144	--------	--------
12	90,985	64,336	52,530	45,492	40,660	37,145	--------	--------

PIPE SIZE INCHES		RETURN MAINS AND RISERS					
Riser	Main	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.
J	*K*	*L*	*M*	*N*	*O*	*P*	*Q*
----	¾	800	568	462	400	358	326
¾	1	1400	994	810	700	626	570
1	1¼	2400	1704	1387	1200	1073	976
1¼	1½	3800	2696	2195	1900	1698	1547
1½	2	8000	5680	4622	4000	3575	3256
2	2½	13,400	9510	7745	6700	5990	5453
2½	3	21,400	15,190	12,360	10,700	9565	8710
3	3½	32,000	22,710	18,490	16,000	14,300	13,020
3½	4	44,000	31,220	25,430	22,000	19,660	17,910

**Different makes
supply and retur
valves, steam tra
and other specialti
vary as to capacit
therefore use size
recommended for ar
particular make
Vertical connectio
to be of same size
valve and trap use
Return horizont
runout to be no le
than ¾ in.**

Copyright, 1927 { AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
Heating and Piping Contractors National Association } **Not to be Reprinted Without Special Permission**

INSTRUCTIONS FOR USING TABLE 15

1. Radiator branches more than 8 ft. in length should be one size larger than shown in Column *I*.

2. It is not generally considered good practice to greatly exceed 1 oz. drop in pressure in each 100 ft. equivalent length of run nor to exceed 1 lb. total pressure drop in any system.

3. These tables apply where pipes are properly reamed. No allowance for defective material or workmanship have been made. (Also see Tables 7 and 8).

4. Capacities based on ¼ lb. condensation per square foot per hour equivalent radiation and actual diameter of standard pipe.

5. Extra length to be added to straight run of pipe, for various fittings and valves to determine equivalent length. (See Table 4).

6. Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run then use figures in corresponding Columns (*B* to *G*) for sizing the entire run.

For example: If the distance from boiler or source of supply to the farthest radiator on the longest main should be 300 ft., all mains are to be sized from Column *D;* if 400 ft., Column *E;* if 600 ft., Column *G*.

Supply risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each riser. Determine the distance to the farthest radiator then use figures in corresponding Columns (*B* to *G*) for sizing each riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *H*. Where riser capacities are found to be in excess of amounts shown in Column *H*, step up to necessary size indicated in that column.

For example: If the distance from the boiler or source of supply to the farthest radiator on a supply riser is 300 ft., that riser is to be sized from Column *D*, providing the amount of radiation does not exceed the amount shown in Column *H*. If the amount exceeds that in Column *H*, use amounts shown in Column *H* for sizing that entire riser.

If another riser taken from the same main as the one indicated is only 200 ft., this riser should be sized from Column C, providing the amount of radiation does not exceed that as shown in Column *H*.

7. The Guide Committee, 1930, after many check-tests, suggest that for practical purposes the pipe sizes on the usual heating system may be determined by using the pressure drop indicated by the longest main and riser on that system, neglecting the separate computations for each separate shorter run.

8. Return mains and risers are to be proportioned according to the equivalent distance in feet, from farthest radiator to the vacuum pump; using capacities in corresponding Columns (*L* to *Q*) for sizing entire return riser (Column *J*) and return main (Column *K*). The return pipe sizes are conservative and are subject to revision upon the completion of pending research investigations.

9. Where it is necessary to drip a supply main, supply riser or branch to a supply riser, same should be dripped separately through a steam trap into vacuum return. Never drip a supply riser into a vacuum return, except through a steam trap.

10. Lift fittings. (See page 362).

11. Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

TABLE 16. PIPE SIZES FOR VACUUM PUMP SYSTEMS, WHERE EQUIVALENT LENGTH OF RUN FROM BOILER OR SOURCE OF SUPPLY TO FARTHEST RADIATOR **Exceeds** 200 FT.

Capacity in Sq. Ft. of Equivalent Radiation

Based on 8 oz. Total Pressure Drop

PIPE SIZE IN.	EQUIVALENT LENGTH OF PIPE FROM BOILER TO FARTHEST RADIATOR, INCLUDING MAIN AND RISER. (See *Note 6*.) Supply Main Dripped and Branches to Risers Dripped—Steam and Condensate flowing in same direction.									MAXIMUM CAPACITIES	
	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	800 Ft.	1000 Ft.	1200 Ft.	Supply Risers Up-Feed	Branches to Supply Risers and Radiators Not Dripped
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*[1]
1	157	111	92	79	70	65	56	49	46	**56**	26
1¼	346	245	200	173	154	141	122	110	100	**122**	58
1½	538	380	310	269	240	220	190	165	155	**190**	95
2	1091	771	630	546	487	446	386	345	315	**386**	195
2½	1797	1270	1036	898	803	734	635	568	518	**635**	395
3	3289	2326	1896	1645	1470	1342	1163	1040	948	**1129**	700
3½	4913	3474	2838	2457	2196	2006	1737	1552	1419	**1548**	1150
4	6950	4914	4022	3475	3106	2828	2457	2196	2011	**2042**	1700
5	12,858	9092	7424	6429	5747	5250	4546	4062	3712	....	3150
6	21,105	14,924	12,168	10,553	9433	8618	7462	6669	6084	....	....
8	43,934	31,066	25,364	21,967	19,638	17,935	15,533	13,880	12,682	....	....
10	80,171	56,689	46,288	40,085	35,836	32,730	28,345	25,334	23,144	....	....
12	128,672	90,985	74,290	64,336	57,516	52,530	45,492	40,660	37,145	....	....
16	240,245	169,879	138,381	121,012	107,389	98,500	84,849	75,917	69,671	....	....

PIPE SIZE INCHES		RETURN MAINS AND RISERS								
Riser	Main	100 Ft.	200 Ft.	300 Ft.	400 Ft.	500 Ft.	600 Ft.	800 Ft.	1000 Ft.	1200 Ft.
M	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*	*V*	*W*
....	¾	1130	800	653	568	505	462	400	358	326
¾	1	1977	1400	1143	994	884	810	700	626	570
1	1¼	3390	2400	1960	1704	1515	1387	1200	1073	976
1¼	1½	5370	3800	3103	2696	2400	2195	1900	1698	1547
1½	2	11,300	8000	6533	5680	5050	4622	4000	3575	3256
2	2½	18,925	13,400	10,940	9510	8460	7745	6700	5990	5453
2½	3	30,230	21,400	17,460	15,190	13,510	12,360	10,700	9565	8710
3	3½	45,200	32,000	26,130	22,710	20,200	18,490	16,000	14,300	13,020
3½	4	62,180	44,000	35,950	31,220	27,800	25,430	22,000	19,660	17,910
4	5	109,300	77,400	63,200	54,920	48,800	44,720	38,700	34,600	31,500
5	6	175,100	124,000	101,200	88,000	78,200	71,700	62,000	55,410	50,450

Different makes of supply and return valves, steam traps and other specialties vary as to capacity, therefore use size as recommended for any particular make. Vertical connection to be of same size as valve and trap used. Return horizontal runout to be not less than ¾ in.

Copyright, 1927 { AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS *Heating and Piping Contractors National Association* } **Not to be Reprinted Without Special Permission**

INSTRUCTIONS FOR USING TABLE 16

1. Radiator branches more than 8 ft. in length should be one size larger than shown in Column *L*.

2. It is not generally considered good practice to greatly exceed 1 oz. drop in pressure in each 100 ft. equivalent length of run nor to exceed 1 lb. total pressure drop in any system.

3. These tables apply where pipes are properly reamed. No allowances for defective material or workmanship have been made. (Also see Tables 7 and 8).

4. Capacities based on ¼ lb. condensation per square foot per hour, equivalent radiation and actual diameter of standard pipe.

5. Extra length to be added to straight run of pipe, for various fittings and valves to determine equivalent length. (See Table 4).

6. Mains are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiators supplied by the main.

Determine equivalent length of run, then use figures in corresponding Columns (*B* to *J*) for sizing the entire run.

For example: If the distance from boiler or source of supply to the farthest radiator on the longest main should be 300 ft., all mains are to be sized from Column *D;* if 400 ft., Column *E;* if 600 ft., Column *G*.

Supply risers are to be proportioned according to the equivalent length of run from the boiler or source of supply to the farthest radiator on each particular riser. Determine the distance to the farthest radiator then use figures in corresponding Columns (*B* to *J*) for sizing each riser; providing the amount of radiation for that riser does not exceed amounts shown in Column *K*. Where riser capacities are found to be in excess of amounts shown in Column *K*, step up to necessary size indicated in that column.

For example: If the distance from the boiler or source of supply to the farthest radiator on a supply riser is 300 ft., that riser is to be sized from Column *D*, providing the amount of radiation does not exceed the amount shown in Column *K*. If the amount exceeds that in Column K, use amounts shown in Column *K* for sizing that entire riser.

If another riser taken from the same main as the one indicated is only 200 ft., this riser should be sized from Column *C*, providing the amount of radiation does not exceed that as shown in Column *K*.

7. The Guide Committee, 1930, after many check-tests, suggest that for practical purposes the pipe sizes on the usual heating system may be determined by using the pressure drop indicated by the longest main and riser on that system, neglecting the separate computations for each separate shorter run.

8. Return mains and risers are to be proportioned according to the equivalent distance in feet, from farthest radiator to the vacuum pump; using capacities in corresponding Columns (*O* to *W*) for sizing entire return riser (Column *M*) and return main (Column *N*). The return pipe sizes are conservative and are subject to revision upon the completion of pending research investigations.

9. Where it is necessary to drip a supply main, supply riser or branch to a supply riser, same should be dripped separately through a steam trap into vacuum return. Never drip a supply riser into a vacuum return except through a steam trap.

10. Lift fittings. (See page 362).

11. Pitch of mains should be not less than ¼ in. in 10 ft.; on horizontal branches to radiators and risers at least ½ in. in 10 ft.

12. In general it is desirable not to have a supply main smaller than 2 in. in diameter. When the supply main is larger than 2½ in. at the beginning, it is desirable that it shall not be smaller than 2½ in. at the end.

PIPING CONNECTIONS

Hartford Return Connection

The Hartford return connection illustrated in Fig. 7 and in other piping layouts in this chapter is recognized as safer and preferable to the use of check valves. In using this connection, the wet return connects through the shortest possible horizontal pipe 2 in. below the normal boiler water line into the pipe which joins the boiler outlet and boiler inlet on the boiler side of the stop valves. By this arrangement, if a careless operator should close the boiler outlet valve and should forget to close the boiler inlet valve, no water below the level of the inlet connection to the loop could leave the boiler.

Connections to Mains

Fig. 8 shows two methods of taking off branches from mains on one-pipe systems. They apply equally well, however, to other systems of up-feed piping. On one-pipe plants the branches are always made one pipe-size larger than the risers or the radiator connections which they serve. The method of carrying a main past an obstructing beam shown in Fig. 9 may be used advisedly with any system of piping.

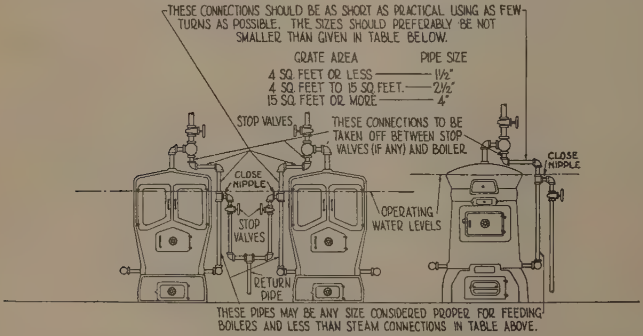

THESE CONNECTIONS SHOULD BE AS SHORT AS PRACTICAL USING AS FEW TURNS AS POSSIBLE. THE SIZES SHOULD PREFERABLY BE NOT SMALLER THAN GIVEN IN TABLE BELOW.
GRATE AREA
PIPE SIZE
4 SQ. FEET OR LESS — 1½"
4 SQ. FEET TO 15 SQ. FEET — 2½"
15 SQ. FEET OR MORE — 4"
STOP VALVES
THESE CONNECTIONS TO BE TAKEN OFF BETWEEN STOP VALVES (IF ANY) AND BOILER
CLOSE NIPPLE
CLOSE NIPPLE
STOP VALVES
OPERATING WATER LEVELS
RETURN PIPE
THESE PIPES MAY BE ANY SIZE CONSIDERED PROPER FOR FEEDING BOILERS AND LESS THAN STEAM CONNECTIONS IN TABLE ABOVE.

FIG. 7. CONNECTING TWO BOILERS USING THE HARTFORD RETURN CONNECTION

Fig. 10 shows a detail of piping at the end of a single-pipe main or at any point where it becomes desirable to rise for a fresh start at a higher level, the steam rising off the top of the main and the water draining down to the wet return below the boiler water line. If the detail shown in Fig. 10 is used at the end of the main, an air valve must be installed above the water line.

Where it is desired to reduce the size of a supply main, an eccentric fitting always must be used, as shown in Fig. 11, or a reducing elbow must be installed, as in Fig. 12, so that perfect drainage is accomplished. These details also apply to any other system of steam piping.

A handy rule for cutting the proper length of offset pipe is illustrated in Fig. 13.

Piping Connections for Vapor and Vacuum Systems

In Figs. 14 to 19, inclusive, are illustrated some of the piping details which are recommended in connection with vapor and vacuum heating. Figs. 14 and 18 show methods of draining and venting the ends of supply mains where a return below the boiler water line is used. Fig. 19 shows the same detail where the return main is above the water line. Fig. 15 shows the method of draining the ends of long branches from supply mains to risers or to remote radiators. Fig. 16 shows a sediment chamber which will catch debris in any vapor or vacuum system, this being cleaned occasionally, preventing the foreign matter from stopping up or injuring the traps or other mechanisms. Fig. 17 illustrates an approved method for carrying a return main which runs near the floor, past a door. The air in the upper part of the main rises freely over the door, while the water passes in the trench under the door.

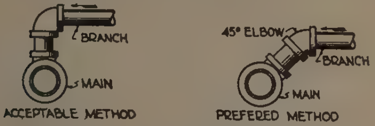


Fig. 8. Acceptable and Preferred Methods of Taking Branch from Main

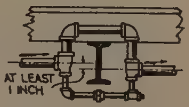


Fig. 9. Looping Main Around Beam

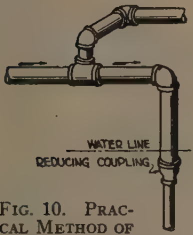


Fig. 10. Practical Method of Dripping Main Where It Rises to Higher Level

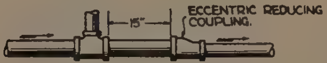


Fig. 11. Practical Method of Reducing Size of Main

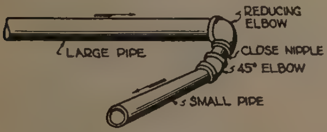
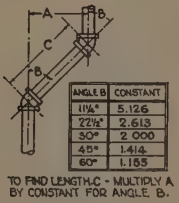


Fig. 12. Reducing Size of Main at Swing Connection



ANGLE B	CONSTANT
11¼°	5.126
22½°	2.613
30°	2 000
45°	1.414
60°	1.155

TO FIND LENGTH C - MULTIPLY A BY CONSTANT FOR ANGLE B.

Fig. 13. Constants for Determining Proper Length of Offset Pipe

Figs. 20 and 21 illustrate approved details of the return pipes leading to vacuum pumps where there must be lifts from low-lying mains up to the pump. These lifts should be avoided wherever possible.

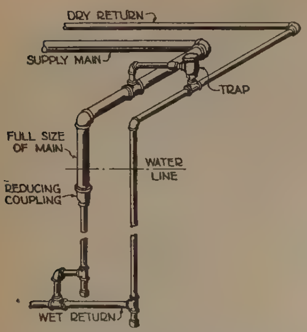


Fig. 14. Dripping Ends of Supply and Dry Return Mains. (The Dry Return is of Course Too Small to be Vented)

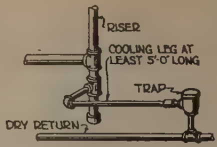


Fig. 15. Dripping Heel of Riser into Dry Return. (A Gate Valve is Recommended at the Inlet Side of the Trap)

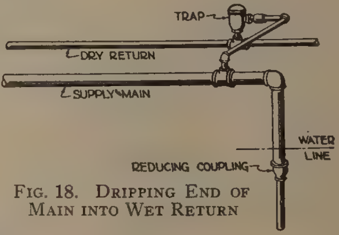


Fig. 18. Dripping End of Main into Wet Return

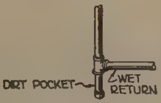


Fig. 16. Dirt Pocket Connection

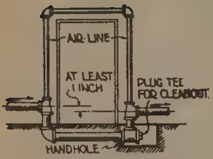


Fig. 17. Looping Dry Return Main Around Opening

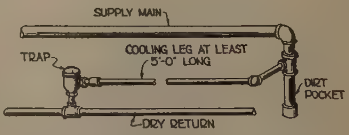


Fig. 19. Dripping End of Main into Dry Return. (A Gate Valve is Recommended at the Inlet Side of the Trap)

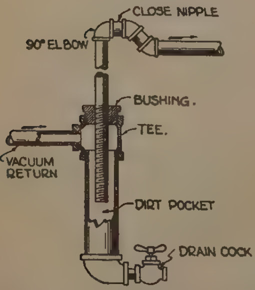


Fig. 20. Detail of Main Lift Fitting to Vacuum Pump

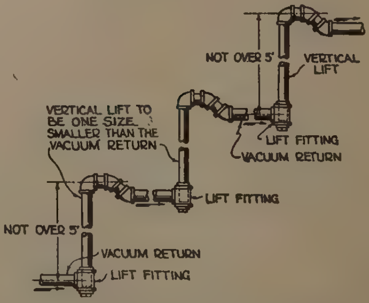


Fig. 21. Series of Lift Fittings Where Lift Is More Than 5 ft.

Heater Connections

Figs. 22, 23 and 24 are typical illustrations of various approved heater connections. They may apply to vapor systems and to vacuum systems.

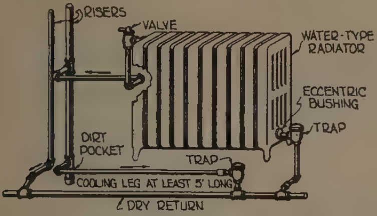


FIG. 22. TOP AND BOTTOM OPPOSITE END RADIATOR CONNECTIONS WITH HEEL OF DOWN FEED RISER DRIPPED INTO DRY RETURN

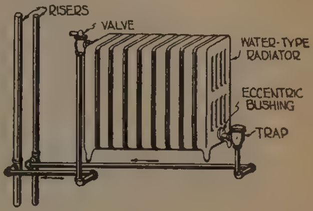


FIG. 23. TOP AND BOTTOM OPPOSITE END RADIATOR CONNECTIONS FROM UP OR DOWN FEED RISERS

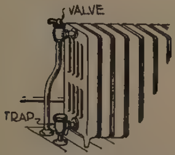


FIG. 24. TOP AND BOTTOM SAME END RADIATOR CONNECTIONS FROM UP OR DOWN FEED RISERS. (NOT TO EXCEED 8 TO 10 SECTIONS).

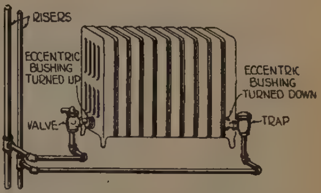


FIG. 25. CONNECTIONS TO STEAM TYPE RADIATOR

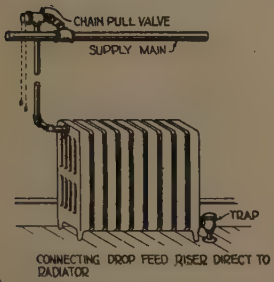


FIG. 26. CONNECTING DROP FEED RISER DIRECT TO RADIATOR BY TURNING VALVE ON ITS SIDE

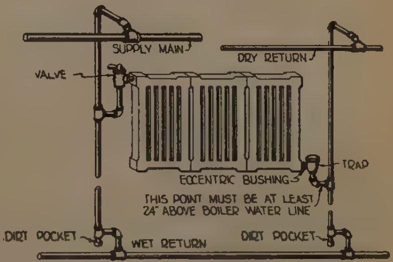


FIG. 27. CONNECTIONS TO RADIATOR HUNG ON WALL

Fig. 25 shows the typical vacuum or vapor system connections to an old-fashioned steam-type radiator. Fig. 26 shows approved connections to a heater below the supply main, with the valve above the main. Fig. 27 shows approved down-feed connections to a wall-type heater with returns

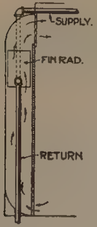


FIG. 28. FIN TYPE RADIATOR NEAR BASEMENT CEILING

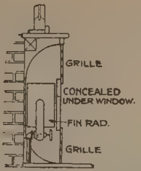


FIG. 29. FIN TYPE RADIATOR CONCEALED UNDER WINDOW

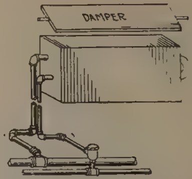


FIG. 30. FIN TYPE RADIATOR CONNECTIONS SAME END

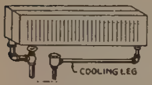


FIG. 31. HORIZONTAL SECTIONAL FIN TYPE RADIATOR

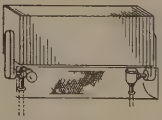


FIG. 32. FIN TYPE RADIATOR VALVES BEHIND GRILLE

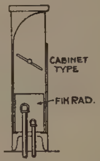


FIG. 33. FIN TYPE RADIATOR CONCEALED IN CABINET

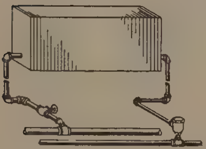


FIG. 34. FIN TYPE RADIATOR WITH VALVES IN BASEMENT

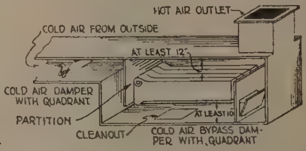


FIG. 35. METHOD OF ENCASING INDIRECT RADIATOR WITH HOT AIR OUTLET IN FLOOR

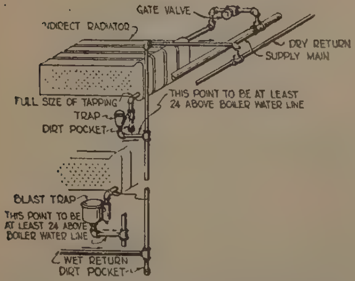


FIG. 36. TYPICAL PIPING CONNECTIONS TO INDIRECT RADIATORS WITH WET RETURN

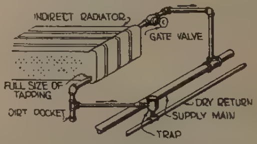


FIG. 37. TYPICAL PIPING CONNECTIONS TO INDIRECT RADIATORS WITH DRY RETURN

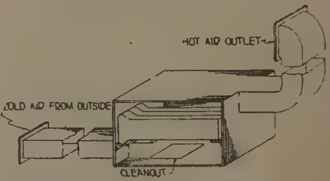


FIG. 38. METHOD OF ENCASING INDIRECT RADIATOR WITH HOT AIR OUTLET IN WALL

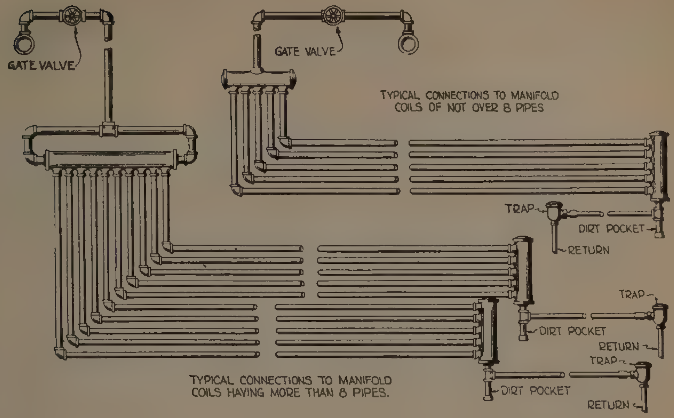

GATE VALVE
GATE VALVE
TYPICAL CONNECTIONS TO MANIFOLD COILS OF NOT OVER 8 PIPES
TRAP
DIRT POCKET
RETURN
TRAP
DIRT POCKET
RETURN
TRAP
TYPICAL CONNECTIONS TO MANIFOLD COILS HAVING MORE THAN 8 PIPES.
DIRT POCKET
RETURN

Fig. 39. Typical Pipe Coil Connections

and drips running to a wet return main. When such an arrangement as this is used for the supply connections it becomes permissible to place the valve at the radiator inlet in the conventional manner.

Figs. 28 to 34, inclusive, illustrate typical approved connections to cabinet-enclosed and other non-ferrous heaters. Connections to such heaters often are troublesome. It is desirable where practicable, to place both the supply valve and the trap in the basement or at least to place them outside of the heater enclosures. It is exceedingly important that no expansion and contraction strains from the piping shall be brought to bear against any convector, since not only damage but also annoying creaking noises may follow such strain.

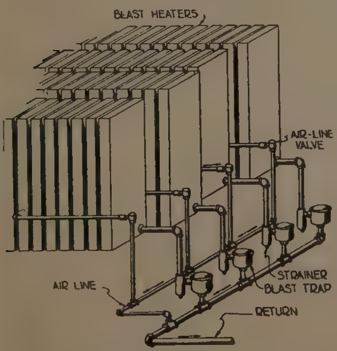


Fig. 40. Typical Connections to Blast Coils Exceeding 12 Sections

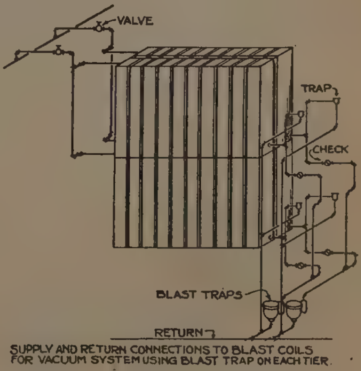

VALVE
TRAP
CHECK
BLAST TRAPS
RETURN
SUPPLY AND RETURN CONNECTIONS TO BLAST COILS FOR VACUUM SYSTEM USING BLAST TRAP ON EACH TIER.

Fig. 41. Connections for Blast Heaters

Figs. 36 and 37 show typical connections to indirect cast iron convector-heaters, and apply to vapor and vacuum systems especially. Figs. 35 and 38 show duct connections to such heaters.

Pipe Coil Connections

Fig. 39 shows practicable piping connections to pipe coils. It is important that the supply valves for all radiators which come below the supply mains shall be above these mains, or that there shall be a drainage connection consisting of a trap or of a pipe leading to the wet return, depending on the type of system, above these supply valves. Without such provision water will condense above the valves when they are closed, and this may cause objectionable noise or damage when the valves are opened.

Blast Heater Connections

Fig. 40 shows vacuum system returns for fan-blast heaters with the auxiliary air vent piping and air-line valves usually required with these heaters, especially when they are of cast iron.

Fig. 41 illustrates another typical blast heater piping hook-up frequently encountered, but with which only the return ends have auxiliary air vents. It is to be noted that while the two super-imposed heaters may drain to a trap common to both, the successive layers of heaters with reference to the air flow from the fan should each have a separate trap, since the condensation rate varies in each successive layer after its predecessor has warmed the entering air.

Unit Heater Connections

When unit heaters are used with steam heating systems the designer must always take into consideration the great condensing capacity of these devices. They must be placed high enough above the boiler water line to compensate for the pressure drop or must be used with systems having pumps or other positive return devices, and must always have pipe connections proportional to their maximum heat emission. Some typical details of unit heater connections are shown in Chapter 9, Unit Heaters and Air Conditioners.

CHAPTER 21

PIPING FOR HOT WATER HEATING SYSTEMS

Determination of Pipe Sizes for Gravity and Forced Circulation Systems; Heat Emission of Hot Water Radiators; Various Arrangements of Piping; Recommended Temperatures; Elbow Equivalents.

IN order to insure satisfactory operation of gravity flow or forced circulation hot water heating systems, careful attention must be paid to design. This is particularly true of gravity systems which must depend for operation upon the small motive forces created by the difference in weight of columns of water of different temperatures.

The principal factors to be considered in the design of the piping system are:

1. The heat losses of the rooms or spaces to be heated.
2. The location and type of radiators.
3. Arrangement of the circuits of the system, including length of pipe and number and type of fittings.
4. The temperature of the water in the flow and return risers.

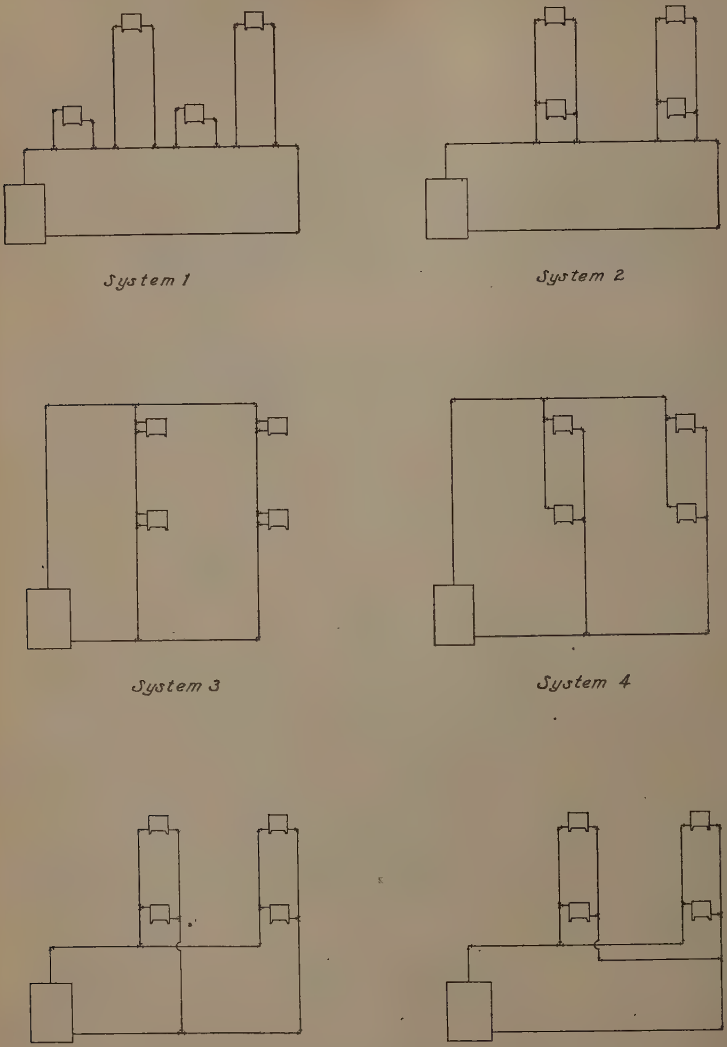
Several different piping systems may be designed for any given combination of heater and radiator. The general rule to apply to the design of a pipe system is that *the friction head leading from the heater to a radiator and back again must equal the pressure head causing the water to flow for that particular circuit.* This rule is based on the condition that the water in the system is circulating with a uniform velocity as is the case when the radiators (and piping) dissipate exactly the same quantity of heat in a given period of time as is delivered to the water in the heater.

The pressure head maintaining circulation through the system may be produced by the difference in the weights of the water in the flow and return risers, in which case the system is a gravity-flow system; or it may be produced by a circulating pump, in which case the system is a forced circulation system.

GRAVITY-FLOW SYSTEM

Before undertaking the design of a pipe system, it is necessary to assume:

1. The maximum temperature of the water leaving the heater when the outside temperature is the minimum for which the system is to be designed.
2. The drop in the temperature of the water while it is flowing through the radiator.
3. The arrangement of the pipe connecting the heater with the several radiators.



System 1

System 2

System 3

System 4

System 5

System 6

Fig. 1. Six Different Methods of Piping a Heating System of Four Radiators

Maximum Water Temperature

It is the custom to select 180 deg. as the maximum temperature of the water leaving the heater. With this maximum temperature and a temperature drop of 20 deg. through the radiator, the average water temperature in the radiator will be 170 deg. If the temperature of the room is to be 70 deg., the temperature difference, water to air will be 100 deg. The corresponding value of *U* (see Fig. 2) for a 38-in., 3-col. radiator, is 1.34 and the heat dissipated by the radiator per square foot per hour is 134 B.t.u. A steam radiator of similar size and design and supplied with low-pressure steam will dissipate about 240 B.t.u. per square foot per hour. Under these conditions a hot water heating system would require about 240 sq. ft. of radiation for every 134 sq. ft. required by the steam heating system. The first cost of the hot water system would, consequently, be considerably greater than that of the corresponding steam system. This higher first cost of a hot water system is frequently the cause of the installation of a steam system.

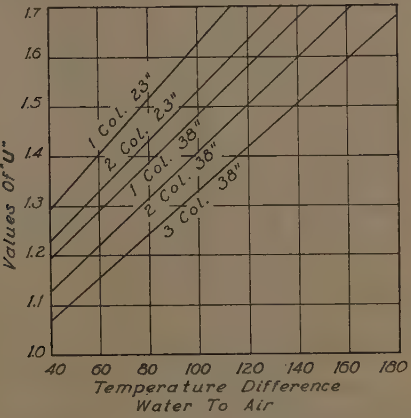


Fig. 2. Suggested Values for the Heat Dissipation Coefficients *U* of Various Types of Hot Water Radiators

If, on the other hand, 220 deg. is selected as the temperature of the water leaving the heater, the average temperature of the water in the radiator will be about 210 deg., practically the same as that in low-pressure steam radiation, and the total radiation required for the hot water system will be about the same as that required for the corresponding steam system. The cost of the pipe system for hot water is probably a little higher than the cost of the pipe system for steam, but the cost of valves and traps for a steam system is greater than the cost of the valves for a hot water system, so that, finally, the cost of a hot water heating system will equal, or it may be lower, than the cost of a corresponding steam heating system, if the water temperature selected is sufficiently high.

The selection of 220 deg. as the maximum water temperature is entirely proper because the minimum outside temperature for which the heating system is designed and for which the heat losses are calculated, occurs only a few times in any one year and perhaps never in some years. Consequently, it is very seldom and in some years never necessary to heat the water to the assumed maximum temperature.

If 220 deg. is selected as the maximum temperature, it is necessary to provide sufficient pressure on the water in all radiators and in the entire pipe system so that the water will not boil at that temperature. This can be accomplished easily in all closed systems and also in all open systems. In the latter case, it is only necessary to place the expansion tank at a sufficient altitude above the highest point in the heating system to secure the desired pressure. For example: If the expansion tank is located 10 ft. above the highest point in the system and if the expansion tank riser is filled with 200 deg. water when the flow risers carry 220 deg. water, the pressure at the highest point of the heating system will be about 4.2 lb. per square inch. The corresponding boiling point is about 226 deg. and there would be no danger of boiling so long as the temperature of the water leaving the heater is not above 220 deg.

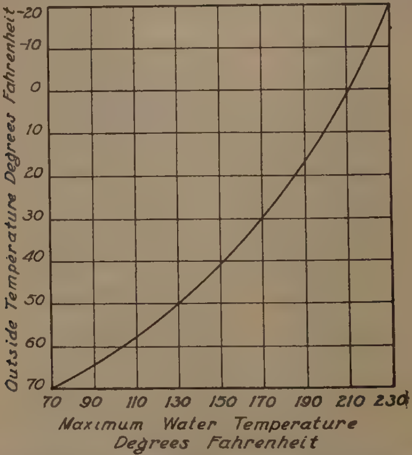


FIG. 3. VARIATION, WITH THE OUTSIDE TEMPERATURE, OF THE REQUIRED MAXIMUM WATER TEMPERATURE IN THE HEATING SYSTEM

In such cases the expansion tank riser should be connected to the return main. Precautions must always be taken to prevent freezing of the water in the expansion tank or in the expansion tank riser.

Having assumed the maximum temperature of the water for the minimum outside temperature, the required water temperature for any other outside temperatures may be calculated and represented by a curve similar to that of Fig. 3, which may be used as a guide by the operating engineer.

Such a curve will, however, not show the correct water temperatures for all times, as heat losses of buildings depend upon the direction and velocity of the wind. The values shown by the curve must, therefore, be modified from time to time by the operating engineer according to the character of the wind prevailing at the time.

Temperature Drop through the Radiator

For any given radiator the drop in the temperature of the water as it flows through the radiator is determined by the quantity of water flowing through the radiator in a given time. For example: If a radiator is to dissipate 10,000 B.t.u. per hour with a temperature drop of 10 deg., it is necessary that 1,000 lb. of water flow through the radiator per hour. If, on the other hand, the temperature drop is to be 20 deg., only 500 lb. of water must flow through the radiator per hour. If, in both cases, the same size pipe is used, the velocity of the water must be twice as high in the former case as in the latter, and since the friction of water in pipes varies almost as the square of the velocity, it follows that the friction head is almost four times as great in the former case as in the latter. If, in both cases, the friction head must have a fixed value—the same as that of the available pressure head—it is evident that the temperature drop through the radiator decreases as the pipe sizes are increased. It has been shown that the required size of the radiator decreases as the temperature drop through the radiator decreases.

Reducing the temperature drop through the radiator raises the average temperature of the water and therefore decreases the sizes of the radiators but increases the sizes of the piping; in other words, it decreases the cost of the radiators but increases the cost of the piping. There is, consequently, an optimum temperature drop through the radiators for every installation, which carries with it the lowest cost of installation. This optimum temperature drop can be determined by a few trial calculations. As a rule, such calculations are never made; the temperature drop is selected arbitrarily.

A temperature drop of from 15 to 30 deg. is common and generally quite satisfactory.

Arrangement of Piping

Having determined the location of the heater and the location of the several radiators, there are a number of ways in which the piping can be arranged to connect the heater and the radiators to secure a system that operates satisfactorily, provided the radiators and the pipes of the system are of correct size so that, in every case, the pressure head for every radiator is exactly equal to the friction head in the circuit of that radiator, when the system is operating at a uniform rate and when each radiator is producing its correct quantity of heat.

Attempts have been made to assign distinctive names to the several methods or types of piping for hot water heating systems. The result is not entirely satisfactory because it is possible to have many variations of each typical method or system of piping. The following definitions will serve to describe the more common general types of piping:

1. A *one-pipe* system is one in which the water flows through more than one radiator before it returns to the heater and, consequently, the radiators farther from the heater are supplied with cooler water than those nearer the heater and in the same circuit.

2. A *two-pipe* system is one in which all water returns to the heater after it has passed through one radiator. In a two-pipe system all radiators are supplied with water at the temperature at which the water leaves the heater, neglecting the cooling which takes place in the pipe leading from the heater to the radiator.

3. An *over-head* distribution system is one in which a main flow riser extends from the heater to the attic, the distributing main is located in the attic, and the return main in the basement.

4. An *under-foot* distribution system is one in which the main flow riser extends only to the basement ceiling, and the main flow line, as well as the main return line, is located below the basement ceiling.

5. A *direct-return* system is one in which the water, after it has passed through a radiator, is returned to the heater along a direct path, so that the total distance traveled by the water is the shortest feasible distance, and so that there are considerable differences in the lengths of the several circuits composing the system.

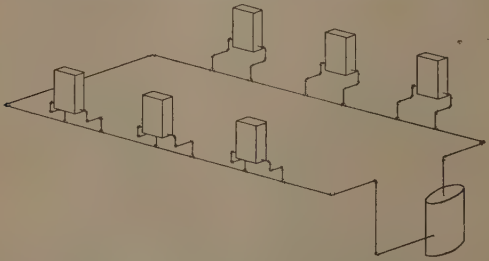


Fig. 4. One-Pipe Gravity Flow Heating System

6. A *reversed-return* system is one in which the water from the several radiators is returned along paths arranged so that all circuits composing the system, or composing major sub-division of the system, are practically of equal length.

A reversed-return system is to be preferred to a direct-return system because it is easier to arrange the circuits so that, in every case, the friction head is equal to the pressure head, and because, in starting the system, all circuits of the reversed-return system begin to function practically at the same time, whereas, in a direct-return system, the longer circuits require considerably more time to begin operating than the shorter circuits.

Determining Pipe Sizes

Having settled on the arrangement of the circuits for the system, generally, for example, by selecting a scheme similar to one of those shown in Fig. 1, it is customary to assume the pipe sizes, and having done that, to calculate the pressure head and the friction head for every circuit. If the two heads happen to be practically equal, the assumed pipe size is the correct one. If there is a material difference between the two, a change is made in the assumed size of the pipe, or of a portion of the pipe, and a new friction head calculation is made. This process is repeated until the correct size has been found.

To illustrate the method, let it be assumed that the one-pipe system with under-foot distribution, as shown in Fig. 4, has been selected, and that the building to be heated requires six radiators, each one transmitting 9,000 B.t.u. per hour. In this case, the system may be assumed to consist of a major and six minor independent elementary heating

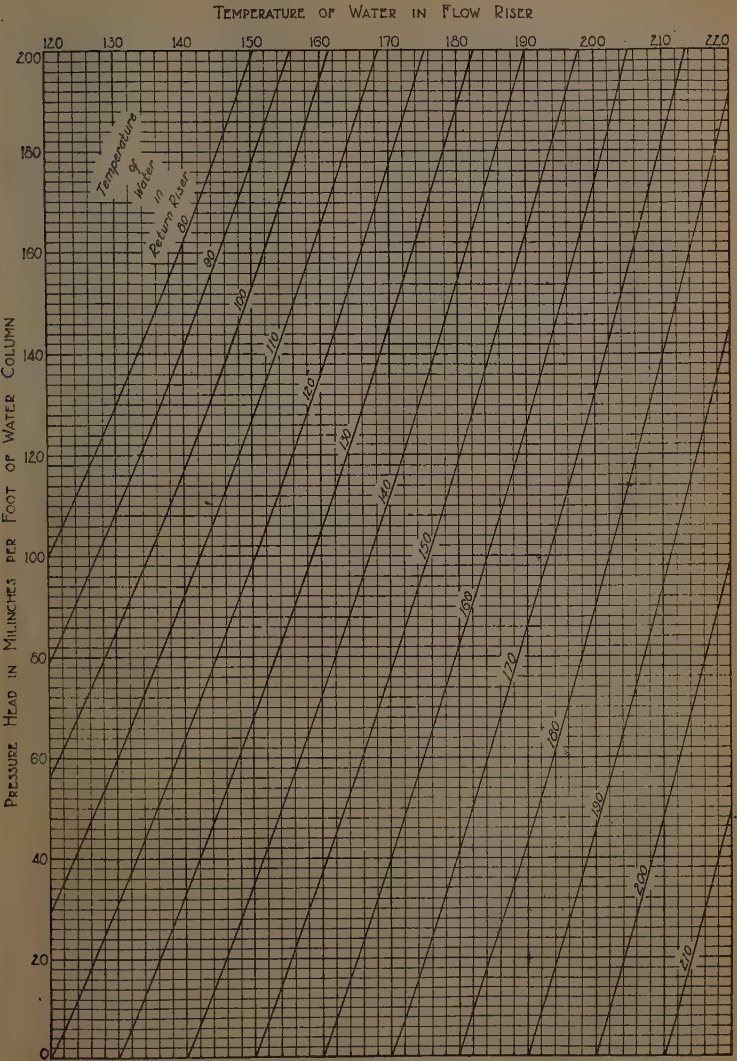


FIG. 5. PRESSURE HEADS FOR VARIOUS TEMPERATURE DIFFERENCES

systems. The major system consists of the heater and the flow main. The six minor systems consist each of one radiator with its flow and return lines connecting the radiator to the flow main.

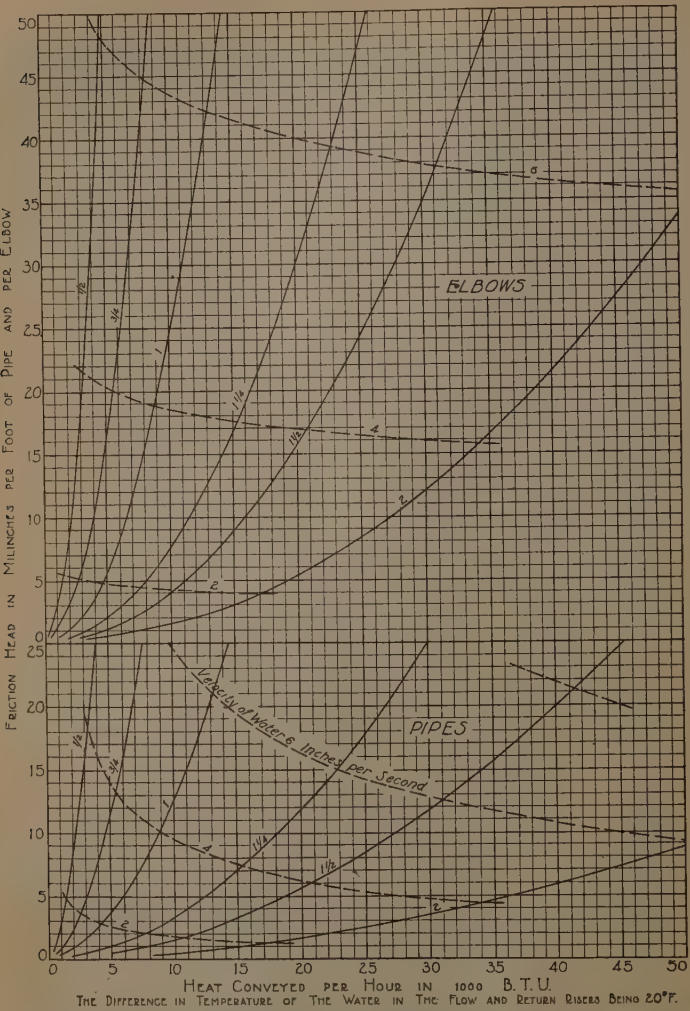


FIG. 6. FRICTION HEADS, IN SMALL PIPES AND ELBOWS, FOR A 20 DEG. TEMPERATURE DIFFERENCE OF THE WATER IN THE FLOW AND RETURN LINES

To design the major system, assume that the system is to operate with a maximum water temperature of 205 deg. and with a temperature drop of 25 deg., that the length of the horizontal main is 125 ft., that the

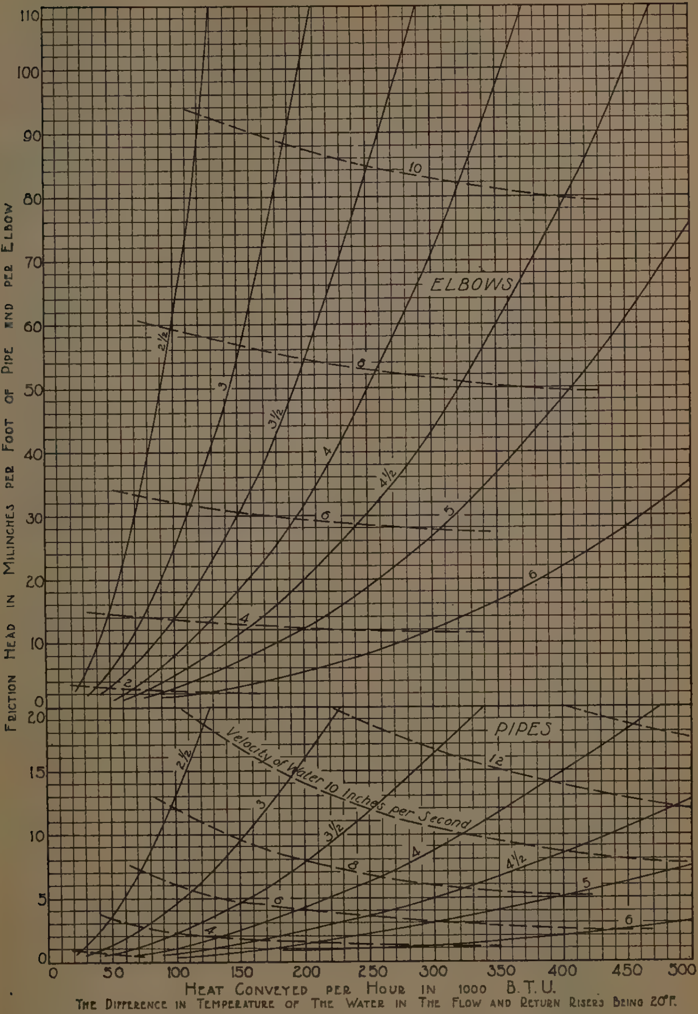


Fig. 7. Friction Heads, in Large Pipes and Elbows, for a 20 deg. Temperature Difference of the Water in the Flow and Return Lines

length of two risers, including heater connections, is 10 ft., and that there are seven elbows in the main, and that the vertical distance from the center of the heater to the average elevation of the main is 3 ft. 6 in.

The pressure head for the main system is produced by the difference in weight of the 205 deg. water in the flow risers and the 180 deg. water in the return risers, the two risers being 3 ft. 6 in. high.

The weight of 180 deg. water is 60.58, and that of 205 deg. water is 60.00 lb. per cubic foot. The difference in the weights of the two columns of water is 3½ x 0.58, or 2.03 lb.

The pressure produced by this weight is the same as that produced by a column of water (of average weight, 60.29), having a height of $\frac{2.03}{60.29}$, or 0.033 ft., or 0.4 in.

TABLE 1. ELBOW EQUIVALENTS

1 90 deg. elbow	1.0
1 45 deg. elbow	0.7
1 90 deg. long turn elbow	0.5
1 Open return bend	1.0
1 Tee	2.2
1 Open gate valve	0.5
1 Open globe valve	12.0
1 Angle radiator valve	2.0
1 Radiator	3.0
1 Heater	3.0

These relations are very nearly correct for the low velocities existing in gravity circulation; for the higher velocities employed in forced circulation, they are sufficiently accurate because every radiator has practically the same number of valves and tees in its circuit and is, therefore, affected equally by any variation from the ratios given above.

Instead of calculating the pressure head, it may be found from Fig. 5, as follows: Find 205 at the upper margin of the diagram, follow the corresponding vertical line downward until it intersects the curved line designated 180. From that point, follow the horizontal line to the left margin of the diagram and read 114 mil-inches per foot of water column. Multiply by 3½, and find 399 instead of 400, as calculated.

The size of the main must now be selected so that its friction head is 400 mil-inches or less. The friction head of the main is made up of the friction heads in 125 ft. of horizontal main, 10 ft. of vertical main and connections, seven elbows, and one heater.

Reference to Table 1 shows that the friction in one heater is equal to that in three elbows; the total friction may then be assumed to be due to 135 ft. of pipe and 10 elbows.

Assume 3 in. as the size of the main and refer to Fig. 7. This diagram is designed for a temperature difference, in flow and return risers, of 20 deg.; in the present example, the temperature difference is to be 25 deg.; the velocity of the water in the main will, therefore, be only $\frac{20}{25}$, or $\frac{8}{10}$ as much as it would be if the temperature difference were 20 deg. Hence, to apply the diagram of Fig. 7, use only $\frac{8}{10}$ of the total heat; *i.e.*, 0.8 × 54,000, or 43,200 B.t.u., and proceed as follows:

Find 43.2 in the lower margin of the diagram, follow the corresponding vertical line to its intersection with the 3 in. pipe line and also with the

3 in. elbow line and read a friction head of 1 mil-inch per foot of pipe, and 5 mil-inches per elbow. The total friction head is 135 × 1, plus 10 × 5, or 185. A 3 in. pipe is too large. Assume a 2½ in. pipe and find the friction head to be 135 × 3, plus 10 × 12, or 525. A 2½ in. pipe is too small. Select a 3 in. pipe or construct the main partly of 3 in. and partly of 2½ in. pipe.

Instead of making the calculation just described, reference may be made to Table 2. Find the horizontal pipe length of 125 ft. in the left column of the table, follow the corresponding horizontal line to the right and note that the capacities of the 2½ in. pipe and the 3 in. pipe are respectively, 44,000 and 75,000 B.t.u. per hour, and conclude that the 2½ in. pipe is too small and the 3 in. pipe too large, as calculated.

TABLE 2. MAXIMUM CAPACITIES IN ONE THOUSAND B.T.U. OF MAINS FOR ONE-PIPE SYSTEMS FOR A DROP IN TEMPERATURE OF 25 DEG. AND A HEAD OF 3 FT. 6 IN.

LENGTH OF HORIZONTAL MAINS, FEET	SIZE OF MAINS—INCHES						
	2	2½	3	3½	4	5	6
50	41	59	100	140	195	346	552
75	35	51	90	130	179	320	500
100	31	48	83	121	165	293	450
125	30	44	75	113	153	280	425
150	27	40	70	104	143	265	405
175	25	38	66	98	136	252	390
200	24	35	63	93	130	239	377
225	23	34	61	90	125	225	367
250	22	33	60	88	120	223	358

Note.—For given capacities, the permissible lengths of the mains are practically directly proportional to the heads. If the head is more than 3 ft. 6 in., the values given in this table may be increased correspondingly.

To design the connections for one of the radiators, *i.e.*, to design one of the six minor systems, proceed as previously described for the design of the major system. Assume that the radiator is on the first floor and that the vertical distance of the radiator tapping above the main is 18 in., that the temperature drop through the radiator is to be 20 deg., and that the average maximum water temperature is to be 195. From Fig. 3, it is evident that the pressure head for the 18 in. column will be 138 mil-inches. The friction head is caused by about 7 ft. of pipe and 16 elbow equivalents. From Fig. 6, it is evident that for 9,000 B.t.u. and a 1 in. pipe, the friction head will be 7 × 10, plus 16 × 20, or 390 mil-inches. A 1 in. pipe is too small. For a 1¼ in. pipe, the friction head will be 7 × 3, plus 16 × 6, or 117. A 1¼ in. pipe is slightly too large. A 1¼ in. pipe would be selected.

Instead of making the calculation just described, refer to Table 3, and note that, for a first-floor radiator, the capacity of a 1¼ in. pipe is 9,500 B.t.u. Table 3 is based on an average water temperature of 180 deg. When the temperature (average) is higher, the capacities are larger.

To find the sizes of the radiators, it must be remembered that the water is cooled as it traverses the system and that each successive radiator is supplied with cooler water and must, therefore, have a larger surface than the preceding one, if it is to transmit an equal quantity of heat. In this particular system, if the first radiator is supplied with 205 deg. water, the sixth one will be supplied with 184⅙ deg. water. The average temperatures of the water in the two radiators will then be about 195 and 175, respectively. The temperature differences, water to air, will be 125 and 104. The values of U will be (from Fig. 2, for a 3-col., 38-in. radiator) 1.34 and 1.28; the heat transmitted will be 125 × 1.34, or 167.5 and 105 × 1.28, or 134.4 B.t.u. per square foot. The first radiator must have $\frac{9,000}{167.5}$ or 53.7 sq. ft., and the sixth radiator $\frac{9,000}{134.4}$, or 66.9 sq. ft. In other words, the last radiator must be about 25 per cent larger than the first, if it is to deliver an equal quantity of heat.

Table 3. Maximum Capacities, in B.t.u., of Risers for One-Pipe Systems

Flow Riser, Inches	Return Riser, Inches	Capacities in B.t.u.		
		First Floor	Second Floor	Third Floor
¾	¾	3,000	6,500	7,800
¾	1	3,700	8,000	9,600
1	1	5,300	11,400	13,600
1	1¼	6,400	14,400	17,100
1¼	1¼	9,500	21,700	26,300
1¼	1½	10,700	25,000	30,600
1½	1½	13,000	30,200	37,900
1½	2	16,000	38,100	46,100
2	2	23,000	55,700	66,800

Note.—Length of pipe:

First floor—7 ft. 0 in.
Second floor—25 ft. 0 in.
Third floor—43 ft. 0 in.

Each circuit has 16-elbow equivalents. This table is based on a temperature drop of 20 deg. through the radiators and an average water temperature of 180 deg. The resulting pressure heads are:

First floor—129 mil-inches.
Second floor—903 mil-inches.
Third floor—1,677 mil-inches.

If the average temperature is higher than 180 deg. the pressure heads are higher than those shown, and if the average temperature is lower than shown, the pressure heads are lower.

Instead of making these complicated calculations for every radiator in a one-pipe system, it may be sufficiently accurate to adopt the following rule:

1. Design each radiator as if it were supplied with water at the maximum temperature used in the system;
2. Divide the heating system into four sections so that each section transmits about one-fourth of the total heat;
3. Number the four sections in the order of their distances from the heater, measured along the flow main, so that the first section radiators receive the hottest water;
4. Adopt the calculated sizes for the radiators in the first section and add, respectively, 10 per cent, 20 per cent and 30 per cent to the sizes calculated for the radiators of the second, third, and fourth sections of the heating system.

The one-pipe system with under-foot distribution, designed as outlined, is probably the system which is easiest to construct so that it will function correctly. The most common error committed in the installation of these systems is that the radiators farthest from the heater are not enlarged sufficiently.

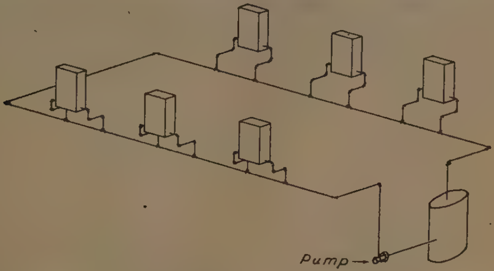


FIG. 8. ONE-PIPE HEATING SYSTEM OF FIG. 4 CHANGED FROM GRAVITY FLOW TO FORCED CIRCULATION

The one-pipe systems with over-head distribution and the two-pipe systems are more complicated, but the underlying principle is the same for all: *The friction head in every radiator circuit must be equal to the pressure head available for that circuit.*

The method of designing the more complicated systems is explained in the respective textbooks to which the reader is referred for additional guidance.

FORCED CIRCULATION SYSTEMS

The principle difference between a gravity circulation and a forced circulation system is that, in the former, the pressure heads are caused entirely by the difference in the weight of the water in the flow and the return risers, whereas, in the latter, the pressure heads are produced largely, in some cases almost entirely, by a pump.

Changing a System from Gravity to Forced Circulation

For example, let Fig. 8 represent the one-pipe gravity circulation system as designed. To change the system from gravity to forced circulation, insert a circulating pump at any point in the main.

With the system designed as a gravity flow system, the total drop in temperature through the system was 25 deg.; the total heat output was 54,000 B.t.u., the quantity of water circulating through the system was $\frac{54,000}{25}$, or 2,160 lb. per hour. The heater pressure head was 0.4 in. The corresponding power was $\frac{2,160 \times 0.4}{12}$, or 72 ft. pounds per hour; or $\frac{1}{27,500}$ hp. Similarly, the power developed by the six-radiator pressure heads may be found to be about $\frac{1}{200,000}$ hp.

After having changed the system from gravity to forced circulation, much more power will be supplied by the pump than was supplied by the gravity pressure heads. Consequently, more water can be circulated through the system, thereby reducing the temperature drop through the system and as a result, smaller radiators and pipes may be used, thereby further increasing the velocity of the water and the power necessary to circulate it.

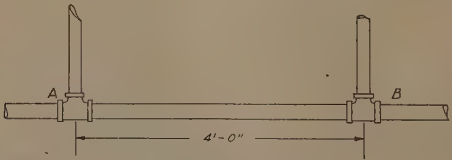


Fig. 9. Radiator Connections for a One-Pipe System Illustrating the Influence of the Pressure Drop in the Main upon the Circulation through the Radiator

Let it be assumed that the total temperature drop is to be 5 deg. instead of 25 deg., and that the main shall be 1½ in. instead of 3 in. In this case the quantity of water circulating through the system will be $\frac{54,000}{5}$, or 10,800 lb. per hour, and the friction head will be 440 mil-inches per foot of pipe and about 1,850 mil-inches per elbow. The total friction head will be about 135 × 440, plus 10 × 1,850, or 6.49 ft. The velocity of the water in the main will be about 42 in. per second. The power required to produce the circulation will be about $\frac{1}{28}$ hp.

Assume that the radiator connections are to be reduced from 1¼ in. to 1 in., and that the distance along the main between radiator connections is 4 ft. as shown in Fig. 9. The pressure head between the points *A* and *B* must be such that it will force 10,800 lb. of water per hour from *A* to *B*. A part of this water moves along the straight pipe from *A* to *B* and the remainder flows through the radiator. The flow through the radiator is caused partly by the pressure head from *A* to *B* and partly by the pressure head produced in the radiator risers; the latter is very small compared with the former and may be neglected, the resulting errors being on the side of safety. Neglecting the radiator pressure head, the flow of water from *A* to *B* will be so that the friction head in the two possible paths will be equal to each other and equal to the pressure head from *A* to *B*. One path consists of a 1½ in. pipe, 4 ft. long; the other, of a 1 in. pipe, 7 ft. long and 16 elbow equivalents. By a few trial calculations it is found that the friction head from *A* to *B* is about 85 per cent of that calculated before, and that about 900 lb. per hour flow through the radiator. The cooling in the radiator must, therefore, be $\frac{9{,}000}{900}$, or 10 deg.

The average temperature of the water will be 200 deg. in the first radiator, and 196 deg. in the sixth. The sixth radiator will be 4 per cent larger than the first instead of 25 per cent as calculated for the gravity system.

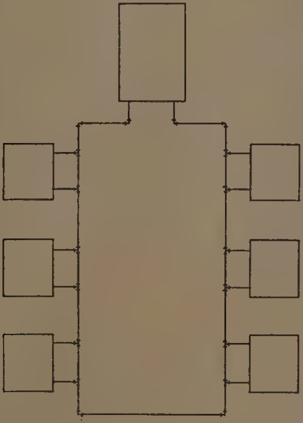


FIG. 10. ONE-PIPE FORCED CIRCULATION SYSTEM FOR SIX BUILDINGS

Relative Economy of Gravity and Forced Circulation

Comparing the economy of the gravity with the forced circulation system it may be concluded that it is more economical to use gravity circulation except when the increased cost produced by installing the pump and by operating, maintaining, and replacing it, when that becomes necessary, is less than the saving effected by using the smaller pipes and smaller radiators, made possible by the use of the pump.

There are some cases where gravity circulation cannot be used. For example: If in Fig. 11 the six rectangles represent six buildings instead of six radiators, each building requiring 500,000 B.t.u. to be supplied from the central plant, it will almost always be necessary to adopt forced circulation for such an installation. The heating main can be arranged as it could be to supply six radiators in a building, as a one-pipe system, Fig. 10; as a two-pipe reversed-returned system, Fig. 11, or as a two-pipe direct-return system, Fig. 12.

The one-pipe system would not be suitable for this installation because the sizes of the radiators, in the buildings receiving the cooler water, would be excessive.

Either of the two-pipe systems shown in Figs. 11 and 12 could be used.

To determine the pipe sizes it is necessary to assume some unit velocity or some unit friction head for the system. The higher the velocity, for which the system is designed, the smaller will be the pipe and its cost, and the larger will be the cost of the pump and of its operation. For every case there will be an optimum velocity for which the total cost is a minimum. This velocity must be calculated for every case.

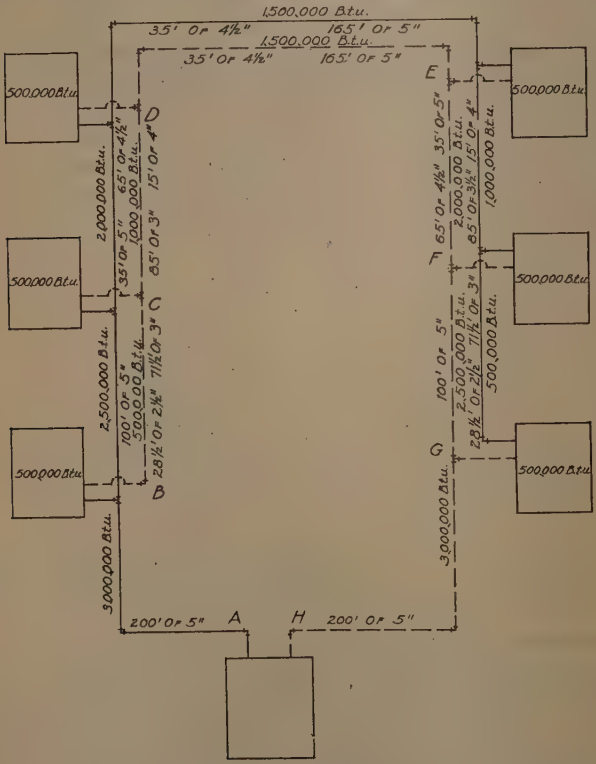


FIG. 11. TWO-PIPE, WITH REVERSED RETURN, FORCED CIRCULATION SYSTEM FOR SIX BUILDINGS

For the system of Fig. 11, assume that the temperature drop through each building is to be 20 deg., and that the velocity of the water in the largest pipe of the main is to be approximately 5 ft. per second and in the smaller generally less, but adjusted so that the friction will be practically the same throughout the system for any one of the six possible paths. Divide the system into seven sections as shown in Fig. 11 and in Table 4.

Table 4. Tabulation of Friction Head Calculations for the Forced Circulation System Shown in Fig. 11

Section	Heat 1,000 B.T.U.	Pipe Length, Feet	Elbows	Pipe Diameter	Velocity	Unit Friction, Mil-Inches		Total Friction, Mil-Inches
						Pipe	Elbows	
A–B	3,000	200	10	5 in.	58	180	2,700	63,000
B–C	2,500	100		5 in.	48	130		13,000
C–D	2,000	100		35 ft. 5 in. 65 ft. 4½ in.	40 45	84 155		13,015
D–E	1,500	200	2	35 ft. 4½ in. 165 ft. 5 in.	36 29	85 50	1,100 690	13,015
E–F	1,000	100		15 ft. 4 in. 85 ft. 3½ in.	32 39	75 140		13,025
F–G	500	100		71.5 ft. 3 in. 28.5 ft. 2½ in.	27 41	82 250		12,988
G–H	3,000	200	10	5 in.	58	180	2,700	63,000
Total Friction Head..........Mil-Inches								191,043

It is evident from Fig. 11 and Table 4 that the water may flow from the central plant through any one of the six buildings and back to the central plant with a loss of head of 15.9 ft. of water, plus the losses of head in the building, and in the central plant. If the six buildings are piped so that the loss of head is the same in each of the six buildings, the water will flow uniformly through the buildings.

If the buildings are piped so that the loss of head is not the same in all, the losses can be made equal by adjusting the valves at the several buildings. For this purpose every building must be supplied with gate valves in the flow and return lines at the building connections and with thermometers in the pipe lines near the valves which should be adjusted so that the calculated temperature drop (20 deg. in this particular problem) is obtained in each building.

Using the prices shown in Table 5, the cost of the 1,600 ft. of mains

Table 5. Approximate Cost of Covered Pipe Installed in Tunnel

Sizes—Inches	2	2½	3	3½	4	4½	5	6	8	10
Cost per Foot....	$0.75	$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.75	$4.50	$6.25

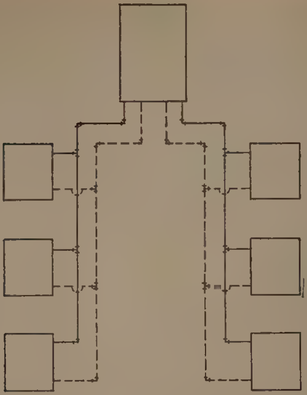


FIG. 12. TWO-PIPE, DIRECT-RETURN, FORCED CIRCULATION SYSTEM FOR SIX BUILDINGS

shown in Fig. 11, is $3,193. Assuming the life of the main to be 20 years and the interest rate 6 per cent, the cost of the main is $278 per year.

The power required to circulate the water through the main is 150,000 × 15.9, or 2,385,000 ft. pounds per hour, or 1.2 hp. Assuming that the power required to circulate the water through the central plant is 15 per cent of the amount stated, that the efficiency of the pump is 75 per cent, and that the cost of current is 2½ cents per kilowatt-hour, the cost of circulating the water is 3.44 cents per hour, or $144 per year if the pump is to be operated 20 × 30 × 7, or 4,200 hours a year.

After completing two additional calculations similar to the one just

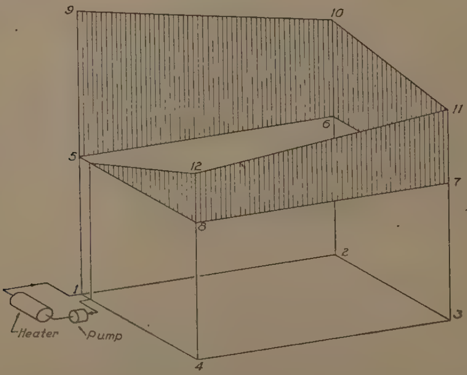


FIG. 13. INFLUENCE OF THE CIRCULATING PUMP UPON THE PRESSURE IN THE FLOW MAIN

described, for the system in which the largest pipes in the main are 4 in. and 6 in. respectively, the following results are obtained:

LARGEST MAIN, INCHES	VELOCITY IN SAME INCHES PER SECOND	TOTAL FRICTION IN FEET	ANNUAL COST	ANNUAL COST OF CIRCULATION	COMBINED COST
4	93	34.8	$221	$316	$537
5	58	15.9	278	144	422
6	40	6.47	340	59	399

This comparison assumes that the cost of the pump is practically the same in the three cases and that the cost of forcing the water through the six buildings remains constant.

Optimum Velocity of Water in Forced Circulation Systems

Based upon these assumptions, the system having the 6-in. main with a velocity of 40 in. per second in that main is the most economical to install.

For this installation the cost of circulating the water would be about 2 per cent of the cost of the heat, if the latter is estimated at 50 cents per 1,000,000 B.t.u., and if it is further assumed that the average heat demand will be one-half of the maximum, *i.e.*, that the average will be 1,500,000 for the plant which was designed for a maximum demand of 3,000,000 B.t.u. per hour.

In a manner similar to that described before, every forced circulation system should be analyzed before definite pipe sizes are adopted.

In large installations it may be found advantageous to transport the heat from the central plant to the central point of a group of buildings by means of high-pressure steam and to install at this central point a heat exchanger and a circulating pump.

Effect of Location of Expansion Tank on Pressure in Forced System

In most central heating systems it is necessary to use an expansion tank. Such a tank is generally installed near the circulating pump and on its suction side; the pump being located in the return line near the heater. With such an arrangement, the pressure in the main remains constant at the suction side of the pump; it rises sharply in the pump and then decreases gradually along the main, as indicated in Fig. 13. In this figure, the line 1, 2, 3, 4, is a base line; the line 5, 6, 7, 8, is a line parallel to the base line drawn so that the distance 1 to 5 represents the pressure in the main when the system is not in operation. This pressure is determined by the elevation of the expansion tank and must be such that sufficient pressure is maintained in the highest radiator to prevent boiling when the water is heated to the maximum temperature for which the system was designed.

The line 9, 10, 11, 12, 5, is drawn so that the vertical distances from its points to the corresponding points of the base line show the pressure in the respective parts of the main when the water is being forced through the main by the circulating pump, neglecting the slight reduction in pressure head caused by the velocity head. An inspection of Fig. 13 shows that, with the expansion tank located at the suction end of the pump, the pressure in the first building is considerably higher than necessary. It also shows that if the expansion tank were located at the line 3, 7, 11, the pressure at that point would remain constant and the pressure would fall below the line 7, 8, 5, and above the line 7, 6, 5. In that case, the expansion tank would need to be at a higher elevation than if located at the pump. This comparison explains the relation which exists between the location and the required elevation of the expansion tank.

In some very large central systems the loss of water from the system is so great that make-up water must be supplied continuously and the expansion tank is not required.

REFERENCES

The Design of Gravity Circulation Hot Water Heating Systems, By Prof. F. E. Giesecke.

Pipe Sizes for Hot Water Heating Systems, By F. E. Giesecke and Elmer G. Smith (JOURNAL, A. S. H. V. E., June, 1929).

Cooling of Water in Iron Pipes, By F. E. Giesecke, *Heating, Piping and Air Conditioning*, August, 1929, p. 267.

CHAPTER 22

PIPING AND EQUIPMENT FOR LAUNDRY, KITCHEN AND HOSPITAL SERVICE

Description of Equipment; Steam, Water, and Power Requirements; Size of Connections; Installation Data.

THE equipment for these highly specialized institutions varies greatly, and only average installations can be treated here. For special cases it is always recommended that consultation be had with specialtists and with manufacturers of this equipment who maintain competent engineering staffs.

In a general way each steam-using unit should have a separate supply valve, with the supply main arranged to drain whether or not the supply valve shall be open, and a separate return trap, draining to a return main placed below the unit.

It is, of course, possible, though not entirely desirable where high-pressure steam is available, to force the condensation up to overhead return mains.

EQUIPMENT FOR LAUNDRIES

Equipment Required

The minimum reasonable equipment of a well-equipped flatwork laundry is as follows:

One 36 x 48-in. washing machine,
One 36 x 64-in. washing machine,
One 26-in. centrifugal extractor,
One 4-roll 90-in. flatwork ironer,
One 30 x 42-in. drying tumbler,
One 2-truck dry room,
One 15-gal. starch cooker,
One 38-in. pressing machine for uniforms, etc.,
One hand-ironing board,
Two 8-lb. electric irons,
Two laundry tubs,
One wringer.

If it is a hospital laundry, one disinfector about 36 in. high by 42 in. wide by 84 in. long, may be included. This is large enough to receive an ordinary hospital mattress without distortion. It is placed in the laundry, rather than elsewhere, for the reason that its principal work consists of disinfecting (or sterilizing) materials which will be laundered.

Such a laundry would meet the requirements of a 250-bed hospital or a 350-room hotel on the basis of a 44-hour operation per week. For a smaller number of people the equipment would be about the same but would be operated fewer hours per week. The purpose of the two washing machines in the minimum laundry is primarily to provide a breakdown service. Washing machines require repairs oftener than any other machines in the laundry and they are indispensable to the operation of the plant.

Water, Steam and Power Requirements

The minimum water, steam and power requirements are about 100 gal. of cold water, 80 gal. of hot water, 30 lb. of steam and 1 k.w. of electricity per 100 lb. of clothes (dry). The average laundry may exceed these as much as 50 per cent and small laundries may exceed this by as much as 100 per cent.

The instantaneous demands for steam and water are much higher than the average demands. Due to the heavy instantaneous demands, especially in a small laundry, it is well to supply the laundry from the main boiler plant, where these drafts will be least felt.

If an individual boiler is installed for the laundry, or for other reason the load curve must be flattened out, the use of larger tanks to obtain more storage capacity is necessary. Tanks double the sizes given in Table 1, are frequently required. In estimating the hot water demand the laundry trays ordinarily may be neglected.

TABLE 1. AVERAGE STEAM, WATER, AND POWER REQUIREMENTS OF WASHING MACHINES

SIZE OF WASHER	DRY CLOTHING PER CU. FT. OF CYLINDER CAPACITY, LB.	HOT WATER PER HOUR, GALLONS	HOT WATER TANK STORAGE, GALLONS	SIZE OF HOT AND COLD WATER CONNECTIONS, IN.	SIZE OF STEAM CONNECTIONS, IN.	ELECTRIC DEMAND, HP.
Small	2	150	100	1½	¾	2
Medium	2	200	150	2	1	4
Large	2	300	200	2	1	6
High Duty	4	600	400	2 (2)	1¼	8

The hot and cold water connections to washers are from 1½ in. to 2 in., depending on size, with ¾ in. to 1 in. steam connections, without returns. The use of oily exhaust steam in washers is objectionable. With alternating current machines an allowance of 100 per cent must be made for reversing.

Ironers usually have steam-heated rolls, and steam pressures of from 70 lb. to 90 lb. are desirable. Occasionally, with light-work, a pressure of 50 lb. will suffice. Each roll of an average sized ironer should have a ¾-in. or 1-in. steam connection, with a ½-in. or ¾-in. trap. The electric motors for ironers are from ¾ to 2 hp., according to size. Electrically heated irons require from 500 to 1,000 watts, according to size.

Tumbler Dryers are rated on diameter and length of cylinder. Each has a small fan, which must have its outlet connected to an outside vent, as it discharges hot, damp air and considerable lint and refuse.

The average machine requires about 600 lb. of steam per hour, and takes an electric motor of from 3 to 6 hp.

The usual steam connection is from 1 to 1¼ in. with a ¾-in. return.

Extractors require from 2 to 5 hp. motors.

Other Laundry Equipment, steam and return services, average as follows:

UNIT	SUPPLY IN.	RETURN IN.
Dry rooms	¾	¾
Starch cookers	½	½
Garment presses	½	½
Disinfector	1	¾

Average water services are as follows:

UNIT	COLD WATER IN.	HOT WATER IN.
Soap tank	½	½
Starch cooker	½	½
Laundry trap	¾	¾

Importance of Soft Water

Soft water, the softer the better, is a necessity if a clean, white wash is to result. With hard water the soap forms insoluble compounds with calcium, magnesium and iron which cling to the washed fibres and after they have been through the flatwork ironer the spots turn various colors. In addition to this, more soap is required with hard waters than with soft; the excess depending upon the amount of hardness present. Before any lather is formed the soap must neutralize the hardness of the water. One pound of average soap will soften (bring to point of producing lather) 167 gal. of water when the hardness is 20 parts per million, but only 40 gal. when the hardness is 100 parts per million. Seventeen parts per million is equivalent to one grain of hardness, by weight, per gallon.

Equipment Arrangement

For efficient operation the arrangement of equipment must be given careful study so that it will fit in with the natural sequence of operations from receipt to delivery. Any backward movements of material that might involve possible contact of washed materials with unwashed material must be guarded against.

Whenever possible the laundry should be in a separate building. The ceilings of the building should be high and the rooms well ventilated by large windows and adequate roof ventilators. Ventilating fans will frequently be required.

All operations except receiving, mending, storing and delivering should be carried on in one room.

EQUIPMENT FOR KITCHENS

The equipment covered herein includes the equipment found in the ordinary institution or hotel kitchen. Nearly all of this equipment can be obtained for gas or for steam. For small kitchens where steam is not always available gas is highly desirable, as it saves the trouble of operating a steam boiler.

Where steam is available it is probably more satisfactory than gas in that it can do no harm if a unit boils dry, whereas with gas under such a unit serious damage might ensue.

For ranges and ovens hard, liquid or gaseous fuels may be used. Electricity finds a wider use for cooking as each day passes.

Water Consumption

Hot water requirements for kitchens may be taken as 20 gal. per hour for each sink faucet and 40 gal. per hour per 1,000 pieces capacity per hour of dishwasher. There is a peak load which occurs at dishwashing time, and this may be met either by instantaneous heaters or by storage type heaters. The requirements of the dishwashing machine are somewhat under control of the operator, for by more liberal use of steam less hot water is used, and vice versa.

Cold water requirements are approximately double the hot water requirements.

Water Connections

Hot and cold water connections to sinks are ¾ in.; hot water only is provided for dishwasher from ½ to 1¼ in. according to size; ½ in. hot and cold water to "bain marie"; and ½ in. cold and hot water to coffee urns. Stock kettles, soup kettles, vegetable steamers, roasting steamers and potato peeler sinks are frequently provided with a ½ in. faucet over each of them, supported independent of the fixture. Generally hot water only is so connected. These are not an absolute necessity but often a great convenience. Drinking fountains and water coolers require ½ in. cold water connections.

In sizing mains to care for two or more items make the mains about one-half the sum of the areas of the branches.

Steam Consumption

The dishwashing machine will consume from 50 to 100 lb. of steam per 1,000 pieces capacity of machine, per hour. An allowance of 150 lb. steam per person per hour will meet all steam requirements for kitchens, except dishwashing machine and water heating.

The average steam requirements for a kitchen serving 300 to 500 persons will be cared for by a 25 to 30 hp. boiler. The annual consumption of such a kitchen will be about 2,000,000 lb. of steam.

Connections for Steam Supply

Steam connections to jacketed kettles, soup kettles, vegetable steamers, steam tables, coffee urns, plate warmers and roll warmers are ½ in. each, for smaller sizes and ¾ in. each for larger sizes and in cases where runs are long. Steam connections to dishwashing machines are ½ to 1¼ in. according to size.

In sizing mains to take care of two or more items make the area about one-half the sum of the branch areas, keeping the sizes well up toward the ends of the runs.

Return Connections

Return connections are uniformly ½ in. size and are made to all kitchen equipment having steam connections, except the spray to dishwashing machine. However, the coil in this machine requires a return connection.

Each unit or separate coil should be provided with a ½ in. thermostatic trap. If more than one unit or coil is connected to the same trap, air binding will result. Connections of the same size as for the traps are made to return mains.

Steam Pressure Limits

Not less than 30 lb. and not over 50 lb. are the usual pressure limits for steam cooking. Lower pressures down to 1 lb. are ample for warmers, but the steam kettles require higher pressures and it is customary to carry the higher pressures mentioned on all equipment. All jacketed pots have safety valves usually set at 50 lb. and usually vacuum breakers are required on the jacketed fixtures to prevent collapse under vacuum conditions.

Grease Traps

The dishwashing machine, all pot sinks, pan sinks and any sinks into which grease may find its way should be provided with grease traps. When grease traps on the individual fixtures are used the cold water supply to the fixture is connected to pass through the jacket of the grease trap.

Connections to Gas Appliances

Obtain from the manufacturer the gas consumption per hour of the different fixtures to be used and size the gas pipes accordingly. Excellent tables for this purpose, when the gas consumption and length of run are known, are given by the *American Gas Association.*

As an approximation the following connections commonly are found in equipment of average size: Bake shop oven, 1¼ in.; pastry oven, ¾ in.; dishwashing machines, ¾ to 1½ in.; broilers, 1 to 1¼ in.; ranges, 1 to 2 in.; small ranges in diet kitchens, 1 in.; salamanders and warmers, ¾ in. and steam tables, 1 in.

Motor Sizes Required

Dishwashing machines require 1 to 2 hp. per 5,000 pieces capacity per hour to drive, with the smallest machine using ½ hp. motor. Kitchen mixing machines take ½ to 1 hp.; bake shop combinations, 2 hp. per barrel rating of machine. The 17 in. meat, food and vegetable choppers require 1 hp. and the 20-in. size requires 2 hp. Coffee grinders, knife polishers, silver burnishers need nominal amounts, about ¼ hp. Vegetable peelers take ¼ to 1 hp. according to size. Allow ½ hp. for a 25-qt. ice-cream freezer and 1 hp. for 40-qt. size.

Electricity Required for Cooking

In a complete electric kitchen, *i.e.*, one in which ranges, broilers and hot-plates are electric, the minimum amount of electricity required for a complete meal is about as follows:

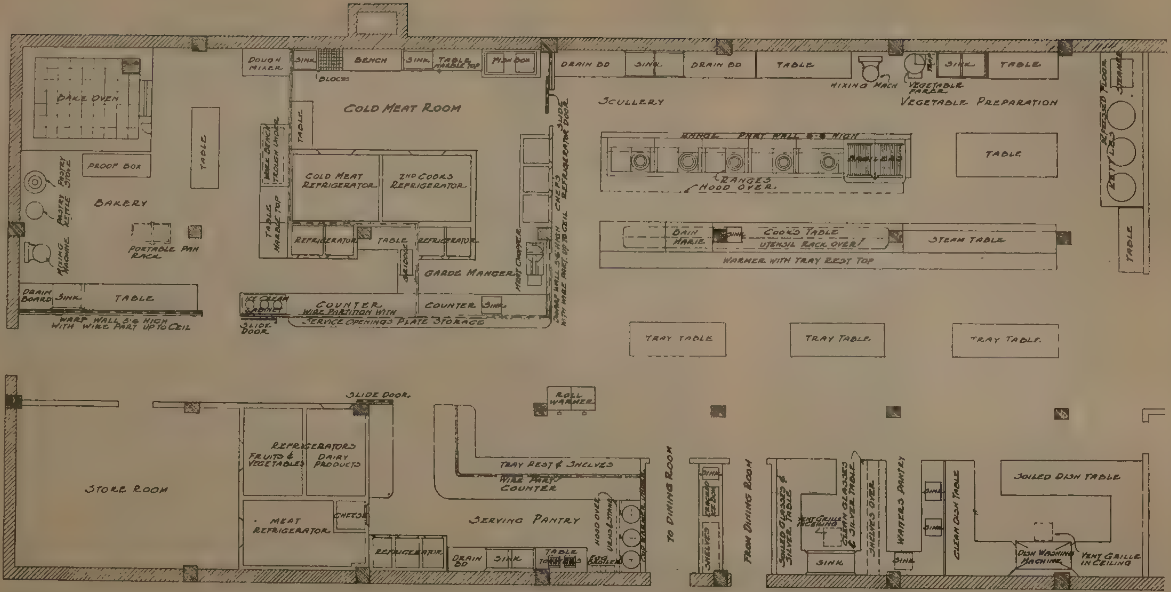


Fig. 1. Kitchen for 500-Room Hotel (Floor Area 5,175 sq. ft.)

General restaurant	400 to 500 watts
Institution kitchen	175 to 200 watts
Colleges, boarding schools, etc.	250 to 350 watts
Clubs, etc.	450 to 600 watts

Electricity is subject to considerable abuse, resulting in waste, unless care is used in its operation. It is easily possible for these figures to be exceeded by 100 per cent and it is probable that they always will be exceeded by some amount.

Fig. 1 shows a kitchen for a 500-room hotel.

EQUIPMENT FOR HOSPITALS

Every modern hospital must sterilize all instruments and utensils used in operations and treatments, all dressings before being used, all bed pans from wards and rooms, the baby's milk and the bottle in which it is served. Provision should also be made to sterilize mattresses, bedding and similar articles and also dishes, when occasion arises. A plentiful supply of sterilized water and distilled water must also be provided. Hospitals for mental and nervous diseases must include hydro-therapy and electro-therapy treatment.

Instrument, dressing, utensil, dish and mattress sterilizers are usually rated by their internal dimensions in inches; water sterilizers by the gallons capacity of each of the two reservoirs, water stills by their capacity in gallons and pasteurizers and bottle sterilizers by their capacity in 8-oz. bottles.

Selection of Sterilizers

Sterilizers and water stills may be had heated by steam, electricity, gas, kerosene or gasoline; the preference being in the order named. Steam is the only method, however, for which the entire line of sterilizers are ordinarily made. Steam sterilizers are simpler, contain less equipment liable to derangement, are quicker in operation and less costly both to install and operate than those heated by any other method. Electrically heated sterilizers, in practice, are confined to the smaller sizes, and such as for dentists' and doctors' treatment rooms outside of hospitals.

Electricity is superior to any other method only in the case of the solution warmer, where, due to its adaptability to automatic control, it is preferable.

Cost of Operating Sterilizers

The cost of operation of steam sterilizer equipment is very little more than the cost of keeping steam constantly available and the amount of use has little effect on the total cost of operation. The cost of operation of electric sterilizers may be considerable; depending upon how much they are used and the cost of *standby* service for them. This will be seen when it is noted that the smallest instrument sterilizer is rated at 2,200 watts and the largest dressing sterilizer at 12,000 watts.

The cost of operation of gas, kerosene and gasoline heated sterilizers is much more than for steam heated ones but usually less than for electric heated ones, depending entirely on the amount of use.

Open and Closed Sterilizers

There are two general classes of sterilizers, *i.e.*, the open type in which the articles to be sterilized are immersed in a water bath heated by steam coils, the limiting temperature obviously being 212 deg. fahr., and the closed type in which there is no water bath and in which the articles to be sterilized are brought into temperatures corresponding to steam at 40 to 60 lb. pressure per square inch.

The open type is older and has the disadvantage of depositing lime or other impurities, which may be in the water, on the instruments, etc., sometimes requiring them to be dried before storing. The latter type is the newer, and obviously provides better sterilization by the higher temperatures obtainable, does not deposit impurities of the water on the instruments, and the articles are dry when removed from the sterilizer. Obviously sterilizers for dressings and fabrics must be of the closed type.

There is considerable tendency now to the use of so-called *built-in sterilizers* in the operating suites and other places where several sterilizers are installed at one point. Only pressure-type sterilizers, which are loaded and unloaded from one end, are adaptable to this arrangement. With this method a thin partition is built flush with the sterilizer fronts, with only the doors, gages and operation valves visible in the rooms, the bodies projecting into an unfinished space behind the partition. This space must of course be accessible for repairs.

Water sterilizers usually consist of twin reservoirs of the same capacity mounted on one frame. One reservoir is for water kept hot by a steam coil in the reservoir and the other is for water somewhat cooled by circulating cold water through a coil in the reservoir. Both reservoirs, of course, have provisions for sterilizing their contents.

Water stills, when so ordered, are part of the water sterilizing unit and consist of still and reservoir, generally mounted between the two water reservoirs.

Where contagious diseases may be handled provision should be made for dish sterilization. On a large scale dishes from contagious patients are sterilized in special sterilizing dishwashing machines. On a small scale however, a 20 x 20 x 24-in. utensil sterilizer fitted with special racks will serve the purpose. The sterilizing dishwashing machines are referred to in the section on equipment for kitchens.

For sterilization of mattresses, see the laundry equipment section of this chapter.

Sterilizers require many small supply and return pipes and the relative amount of steam used by such equipment is almost negligible if drawn from a central boiler plant.

A ½-in. supply and return connection is ample for almost any utensil, instrument or dressing sterilizer. Water sterilizers up to 15 gal. use ¾-in. supply and ½-in. return, and above that size 1-in. supply and ½-in. return. Water stills up to 6 gal. use ½-in. supply and return.

When sizing the steam and return mains it may be assumed that all sterilizers will be in use at one time in a small hospital and half of them in a large hospital. The mains can then be sized by the usual table of equalization of pipe sizes. A return main one half the diameter of the steam main, with ¾-in. as minimum size, may be used.

The uniform practice is to provide a separate thermostatic trap on the return from each coil or unit, of the size given previously for return connection. The return main should itself be vented and condensation should return by gravity to a vented receiving tank.

When gas is used a ½-in. connection is made to each instrument, dressing and utensil sterilizer. Water sterilizers up to 15 gal. capacity should have ¾-in. gas line and above that size 1-in. line. The mains should be sized on an equalization basis the same as explained for steam supply lines, assuming all sterilizers in use at the same time in a small hospital and half of them in use at the same time in a large hospital.

Waste and Vent Connections

All sterilizers in which the articles to be sterilized are more or less immersed in water which is in turn heated by the steam, must have waste connections similar to plumbing fixtures. With the exception of the bedpan sterilizer in which the trap is part of the fixture, traps on these waste lines must be provided in the plumbing work, the sterilizer equipment merely including a valve on the waste line and pipe to floor or wall, as may be required.

Waste connections are seldom more than ¾ in. at the fixture. As the usual sanitary fittings for plumbing work are not standard in sizes less than 1¼ in. it is customary to provide traps and connections 1¼ in. in size from the wall or floor line, as the case may be, to the waste piping of the plumbing system.

Waste connections from bedpan sterilizers are uniformly made 3 in. and the trap is part of the fixture, connected to floor or wall as required. This sterilizer waste should be connected to the drainage system in a manner similar to that for a slop sink or water closet.

Vent connections are also necessary on such sterilizers to avoid the nuisance of steam and vapor in large quantities, which escape into the room, when a sterilization is finished. Such connections usually take the form of a combined overflow and vent, connected at rear of the chamber near the top. This combined connection is usually carried as one horizontal pipe to a suitable location, as close to the sterilizer as possible, where the vent is taken upward directly to the atmosphere, and the overflow and condensation waste is taken from the bottom through a suitable trap and connected to the waste lines of the plumbing system or connected to the waste from the body of the sterilizer between the trap and the sterilizer.

The usual sizes of combination overflow and vent connections to open sterilizers are as follows: Utensil sterilizers, 1¼ in. up to 16 x 15 x 20-in. size and 2 in. for larger sizes; instrument sterilizers, 1¼ in. for all sizes; milk pasteurizers and sterilizers, 1¼ in. up to 72-bottle size and 2 in. for larger sizes and for bedpan sterilizers, 2 in. Vents to atmosphere are the same size as the combination overflow and vent. The overflow connection to the plumbing waste pipes from the combination vent and overflow is 1¼ in. in all sizes of all sterilizers and is generally connected to the waste from the sterilizer body between trap and sterilizer.

Where practicable it is well to run the vents from sterilizer equipment through the roof separate from other plumbing vent lines and to make them extra heavy galvanized pipe, since corrosion is very rapid. A 2-in. vent line will carry several sterilizers. In climates where freezing weather often occurs it is necessary to make the vents at least 4 in. in size through the roof to avoid frosting over.

Care must be taken to see that the bases or heels of vent lines from sterilizer equipment are drained through suitable traps into the waste lines of the plumbing system, to take care of condensation which might otherwise cause a nuisance by draining back into the sterilizer.

Closed, or pressure-type sterilizers, both jacketed and otherwise, each require a vent to the atmosphere connected to the chamber and provided with a valve. The relief valve, with which every closed sterilizer must be provided, usually is connected to this vent line on the line-side of the control valve. These vents are generally ¾ in. from each sterilizer, but the vent lines, after the wall or floor is reached, are made 1¼ in.; the bases or heels of the vent pipes must be dripped into the plumbing system and the vents should be carried through the roof separately just as described for open sterilizers.

Some sterilizers are provided with exhaust condensers, which use cold water to condense the surplus steam. They should never be connected with the plumbing system without an air break, usually a funnel, with a 1¼-in. outlet and a trap.

The water connection to the exhaust condenser usually is ½ in.

REFERENCE

Selecting and Operating Laundry, Kitchen and Hospital Equipment, By H. C. Russell (JOURNAL, A. S. H. V. E., December, 1928, p. 847).

CHAPTER 23

WATER SUPPLY PIPING FOR BUILDINGS

Hot and Cold Water Supply; Riser, Main, and Connection Sizes.

THE water supply formulae herewith make it possible accurately to compute the flow of water in gallons or cubic feet through any pipe with any friction head. The formula is also given for the additional head due to water entering the main. If extremely accurate calculations are necessary, this head should be added to the head required for friction; generally, however, it can be neglected as it is comparatively small.

WATER SUPPLY FORMULAE

CF = cubic feet per minute discharged.
G = gallons per minute discharged.
H = friction head of water in feet = pressure × 2.31; if water is raised vertically, deduct number of feet raised, from head due to pressure.
L = length of pipe in feet—including horizontal and vertical runs.

$$CF = 0.16\sqrt{\frac{(3d)^5 \times 3\ H}{L}} \qquad (1) \qquad\qquad G = 1.2\sqrt{\frac{(3d)^5 \times 3\ H}{L}} \qquad (2)$$

$$H = \frac{(CF)^2 \times L}{0.0768\,(3d)^5} \qquad (3) \qquad\qquad H = \frac{(G)^2 \times L}{4.32\ (3d)^5} \qquad (4)$$

These formulae neglect the head due to entry, which need not be computed except when L is very short. H_1 = head due to entry in feet.

$$H_1 = \left(\frac{0.83\ G}{d^2 \times 13}\right)^2 \text{ or } H_1 = \left(\frac{6.25\ CF}{d^2 \times 13}\right)^2$$

Example: Required the discharge of a 2-in. main with pressure 30 lb. 100 ft. horizontal run and 30 ft. vertical run.

$H = 30 \times 2.31 - 30 = 39.3.$ Formula (2) $G = 1.2\sqrt{\frac{(3 \times 2)^5 \times 3 \times 39.3}{100 + 30}} = 100.8$ gallons per minute.

In this case the head due to entry would be $H_1 = \left(\frac{0.83 \times 100.8}{2 \times 2 \times 13}\right)^2 = 2.56$ ft.

Usually this can be neglected except for very close calculations.

Friction caused by elbows should be added to straight pipe friction. Each elbow in a line will add friction equal to a length of straight pipe forty times the diameter of the pipe:

Pipe Size	¾	1	1¼	1½	2	2½	3	3½	4
Equivalent length of straight pipe in feet	2.5	3.3	4.1	5	6.7	8.3	10	11.7	13.3

TABLE 1. COLD WATER BRANCH SUPPLY SIZES FOR FIXTURES AND MAXIMUM FLOW IN GALLONS PER MINUTE

	NUMBER OF FIXTURES									
	1	2	4	8	12	16	24	32	40	
Water Closets—										
Gal. per Min.	8	16	24	48	60	80	96	128	150	Tanks
Pipe Size	½	¾	1	1¼	1½	1½	2	2	2	
Gal. per Min.	30	50	80	120	140	160	200	250	300	Flush
Pipe Size	1	1¼	1½	2	2	2	2½	2½	2½	Valves
Urinals—										
Gal. per Min.	6	12	20	32	42	56	72	90	120	Tanks
Pipe Size	½	¾	1	1¼	1¼	1¼	1½	2	2	
Gal. per Min.	25	37	45	75	85	100	125	150	175	Flush
Pipe Size	1	1¼	1¼	1½	1½	2	2	2	2	Valves
Lavatories and Wash Sinks—Based upon Each Faucet										
Gal. per Min.	4	8	12	24	30	40	48	64	75	
Pipe Size	½	½	¾	1	1	1¼	1¼	1½	1½	
Bath Tubs—										
Gal. per Min.	15	30	40	80	96	112	144	192	240	
Pipe Size	¾	1	1¼	1½	2	2	2	2½	2½	
Shower Baths—										
Gal. per Min.	8	16	32	64	96	128	192	256	320	8″ rain
Pipe Size	½	¾	1¼	1½	2	2	2½	2½	3	Head
Acid and Slop Sinks, Manufacturing, Kitchen and Laundry—										
Gal. per Min.	15	25	40	64	84	96	120	150	200	per bibb
Pipe Size	¾	1	1¼	1½	1½	2	2	2	2½	per bibb

Note.—The above sizes are based upon a pressure drop of 30 lb. per 100 ft.

In estimating risers and mains, the number of gallons for W. C. and urinals where flush valves are used are to be as given for tanks.

The hot-water faucets are to be disregarded when estimating cold-water risers and mains.

TABLE 2. COLD WATER SUPPLY RISERS FOR BUILDINGS OTHER THAN RESIDENCES

	G. P. M.	G. P. M.	PIPE SIZE WITH DROP PER 100 FT. RUN		
			5 lb.	10 lb.	20 lb.
10th Story	100 x 0.60	60% = 60	2″	2″	1½″
10 and 9	200 x 0.60	90% = 108	2½″	2½″	1½″
10 and 9 and 8	300 x 0.60	80% = 144	3″	2½″	2″
10 to 7 incl.	400 x 0.60	70% = 168	3½″	3″	2½″
10 " 6 "	500 x 0.60	60% = 180	3½″	3″	2½″
10 " 5 "	600 x 0.60	50% = 180	3½″	3″	2½″
10 " 4 "	700 x 0.60	40% = 184	3½″	3″	2½″
10 " 3 "	800 x 0.60	40% = 192	3½″	3″	2½″
10 " 2 "	900 x 0.60	40% = 216	3½″	3″	2½″
10 " 1 "	1000 x 0.60	40% = 240	3½″	3″	2½″

Note.—For residences, use Table 1, and for the main supply use 25 per cent of total of gallons used by fixtures and then take pipe size from Table 5 on a basis of 10 lb. pressure drop per 100 ft. or less if water supply pressure is less than 50 lb.

Table 1 gives the amount of water in gallons which should flow per minute for the number of fixtures indicated of each different type, together with the branch pipe size necessary to carry this amount of water with a pressure drop of 30 lb. per 100 ft. of run.

The volume of water required per fixture is reduced as the number of fixtures in each group is increased, to take care of the factor of probable use.

For size of mains for residences, ascertain the total number of gallons per minute, connected load, from Table 1. Select the pipe diameter from

TABLE 3. APARTMENT HOUSE SUPPLY RISERS

Based upon One, Two, and Three Baths per Apartment

ONE (1) BATH APARTMENT		TWO (2) BATH APARTMENT		THREE (3) BATH APARTMENT	
1 bath	15 gal.	2 baths	24 gal.	3 baths	30 gal.
1 W. C.	8 gal.	2 W. C.	14 gal.	3 W. C.	18 gal.
1 sink	4 gal.	1 sink	4 gal.	1 sink	4 gal.
1 lav.	4 gal.	2 lavs.	6 gal.	3 lavs.	9 gal.
	31 gals.		48 gals.		61 gals.
50% demand—15 gals. per min.		40%—20 gals. per min.		40%—24 gals. per min.	

		Riser		Riser		Riser
Top Floor	15 gal.	1¼″	20 gal.	1¼″	24 gal.	1¼″
Next	28 “	1¼″	38 “	1½″	43 “	2″
“	38 “	1½″	54 “	2″	64 “	2″
“	51 “	2″	68 “	2″	82 “	2″
“	60 “	2″	80 “	2″	96 “	2½″
“	67 “	2″	90 “	2″	108 “	2½″
“	71 “	2″	98 “	2½″	117 “	2½″
“	78 “	2″	104 “	2½″	124 “	2½″
“	81 “	2″	108 “	2½″	134 “	2½″
“	83 “	2″	110 “	2½″	143 “	2½″
“	84 “	2″	110 “	2½″	143 “	2½″
“	85 “	2″	110 “	2½″	143 “	2½″

Note.—The pipe sizes are based upon a drop of 10 lb. water pressure for each 100 ft. run. The size of branch for each Apartment should be not less than 1¼ in.

TABLE 4. APARTMENT HOUSES. SIZES OF WATER SUPPLY MAINS AND METERS

Based upon pressure drop of 10 lb. per 100 ft. run

FOR 4 AND 5 STORIES

Apartments per Story

	FOUR		SIX		EIGHT		TEN	
	Gal.	Main	Gal.	Main	Gal.	Main	Gal.	Main
1 bath	120	2½″	160	3″	200	3″	240	3″
2 baths	160	3″	200	3″	240	3″	280	3″
3 baths	200	3″	240	3″	280	3″	320	3½″
FOR 6, 7 AND 8 STORIES								
1 bath	150	2½″	190	3″	230	3″	270	3″
2 baths	190	3″	230	3″	270	3″	310	3½″
3 baths	230	3″	270	3″	310	3½″	350	3½″
FOR 9, 10, 11 AND 12 STORIES								
1 bath	200	3″	250	3″	300	3½″	350	3½″
2 baths	250	3″	300	3½″	350	3½″	400	3½″
3 baths	300	3½″	350	3½″	400	3½″	450	4″

Note.—This table gives the sizes of mains for apartment houses of one, two or three baths for each apartment, and with four, six, eight or ten apartments per story and from four to twelve stories in height.

Note.—The gallons per minute given in this table are approximated maximum demand for conditions stated.

Table 5 on the basis of a demand of 25 per cent of the connected load and a 10-lb. pressure drop per 100 ft.

For risers in residences use the pipe sizes in Table 1.

TABLE 5. AMOUNT OF WATER IN GALLONS PER MINUTE WHICH WILL FLOW THROUGH VARIOUS SIZED PIPES FOR VARIOUS PRESSURE DROPS

FRICTION PRESSURE DROP POUNDS PER SQUARE INCH PER 100-FT. RUN	PIPE SIZES IN INCHES								
	¾	1	1¼	1½	2	2½	3	3½	4
5	5.4	11	19	30	62	109	171	252	353
7	6.4	13	23	36	74	129	203	298	418
10	7.6	15	27	43	88	154	242	357	499
20	10.8	22	38	61	125	218	343	504	706
30	13.2	27	47	76	153	267	420	618	864
40	15.0	31	54	86	176	308	485	714	998
50	17.0	35	60	96	197	345	542	800	1115
75	21.0	43	74	117	242	423	665	978	1365
100	24.0	49	85	136	278	485	769	1130	1578
125	27.0	55	96	152	311	544	858	1260	1765
150	30.0	60	105	166	341	598	939	1380	1930

TABLE 6. WATER PRESSURE REQUIRED TO DELIVER WATER TO TOP OF VERTICAL RISER WITH 15 LB. PRESSURE AT THE TOP BRANCH AND TO GIVE ADEQUATE SERVICE AT VERTICAL HEIGHTS GIVEN

WATER PRESSURE IN LB. REQUIRED TO DELIVER WATER TO TOP OF RISER WITH 15 LB. TERMINAL PRESSURE[a]				STATIC HEAD IN LB. PER SQ. IN.	VERTICAL RISE OF WATER FROM MAIN TO HIGHEST FIXTURE BRANCH	WATER PRESSURE IN LB. REQUIRED TO GIVE ADEQUATE SERVICE AT VERTICAL HEIGHTS GIVEN[b]			
Pressure Drop per 100 Ft.						Horizontal Run from Supply to Riser			
5 lb.	7 lb.	10 lb.	20 lb.			25′ 0″	50′ 0″	75′ 0″	100′ 0″
15	15	15	15	0	0	22.8 lb.	25.3 lb.	27.8 lb.	30.3 lb.
20.5	20.7	21	22	4.33	10	28.1 "	30.6 "	33.1 "	35.6 "
25	25.4	26	28	8.66	20	33.5 "	36 "	38.5 "	41 "
29.5	30.1	31	34	12.99	30	38.8 "	41.3 "	43.8 "	46.3 "
35	35.8	37	41	17.32	40	44.1 "	46.6 "	49.1 "	51.6 "
39.5	40.5	42	47	21.65	50	49.5 "	52 "	54.5 "	57 "
44	45.2	47	53	25.99	60	54.8 "	57.3 "	59.8 "	62.3 "
49.5	50.9	53	60	30.32	70	60.1 "	62.6 "	65.1 "	67.6 "
54	55.6	58	64	34.65	80	65.2 "	67.7 "	70.2 "	72.7 "
58.5	60.3	63	72	38.98	90	70.8 "	73.3 "	75.8 "	78.3 "
64	66	69	79	43.31	100	76.1 "	78.6 "	81.1 "	83.6 "
68.5	70.7	74	85	47.64	110	81.5 "	84 "	86.5 "	89 "
73	75.4	79	91	51.97	120	86.8 "	89.3 "	91.8 "	94.3 "
77.5	80.1	84	97	56.30	130	92.1 "	94.6 "	97.1 "	99.6 "
83	85.9	90	104	60.63	140	97.5 "	100 "	102.5 "	105 "
87.5	90.5	95	110	64.96	150				

[a] The water pressures given in this table are the pressures at the base of the riser, necessary to deliver water to top of riser with a terminal pressure of 15 lb. when discharging the number of gallons per minute called for in Table 5, at the pressure drop indicated.

[b] Based upon 10 lb. pressure drop per 100 ft. run of pipe and a terminal pressure of 15 lb. at the uppermost fixture. A terminal pressure of 15 lb. has been selected for operation of flush valves. For terminal pressure of 10 lb., deduct 5 lb. from the figures given above; or for a terminal pressure of 5 lb., deduct 10 lb. from above values.

In estimating the pipe size for any part of a riser in a building of several stories, take 60 per cent of the water to be used on any story and all stories above as determined from Table 1 and deduct 10 per cent for each story above. This reduction in estimated amount is to take care of probable use. Thus, if 100 gal. per minute are used on each story of a 10-story building the size of pipe will be determined as in Table 2.

The pressure drop of 30 lb. per 100 ft. of run will give satisfactory results for branches on the top story. A higher pressure drop can be used on stories below, corresponding with the pressures as given in Table 5, which shows that for a building 100 ft. in height, a pressure drop of 100 lb. can be used on the lowest fixture branches, and that for a building 50 ft. in height, a pressure drop of 52 lb. can be used on the lowest fixture branches. Table 1, however, can be used with safety on any of the stories but will give pipe sizes larger than necessary for the lower stories in a very tall building.

Tables 3 and 4 may be used alternatively with Table 2, being adapted for very rapid determinations in the case of large apartment houses.

Example: What is the riser size needed for a six-story apartment house having one bath for each apartment?

Table 3 gives 2 in. diameter for all from four to twelve stories with 1¼ in. to supply the top story and next to top and 1½ in. for story below.

What is the size of riser needed for a twelve-story apartment house with three baths to each apartment?

Table 3 gives 2½ in. for all stories up to eighth floor, 2 in. for ninth, tenth and eleventh, and 1¼ in. for top story.

What is the riser size for a two-bath apartment six stories high?

Table 3 gives 2 in. for the first four stories with 1½ in. at fifth story and 1¼ in. on the top story.

Example: What is the required size of water main for apartment house eight stories high, six apartments per story, each having three baths?

Answer from Table 4 is 3 in.

Example: What is the required size of main for a ten-story apartment house with six apartments per story, each having two baths?

Answer from Table 4 is 3½-in. main.

Table 5 gives the amount of water in gallons per minute which may be passed through pipes of ¾ in. to 4 in. diameter with pressure drops of from 5 lb. to 150 lb. per 100 ft. of run. This table may be used in sizing horizontal and vertical mains.

For example: If the water main pressure available is known, say 90 lb., and the horizontal run from water main to vertical riser is 100 ft., and the vertical riser is 100 ft. to top branch, it will require 43.31 lb. for static head (see Table 6), and 15 lb. pressure at a minimum should be allowed for the uppermost fixture, or a total of 58.31 lb.; which would leave available for friction 90 − 58.31 = 31.69 for friction in 200-ft. run, or 15.85 lb. per 100 ft. The main can thus be sized from the 20 lb. pressure drop of Table 5.

Example: What are the sizes required for mains and branches in a building 100 ft. high, supplied with a water pressure of 75 lb. per square inch with 100 gal. of water per minute required on each story?

This is worked out in Table 2 and gives the pipe sizes for the main riser with a 10-lb. drop for 100 ft. of run and shows that a 3-in. main, reduced to 2 in. would be required. Branches to the various groups of

TABLE 7. HOT WATER REQUIREMENTS FOR APARTMENT BUILDINGS

CLASS	HOT-WATER FIXTURES PER APARTMENT						GALLONS HOT WATER PER APARTMENT PER MAXIMUM HOUR
	Lavatories	Bath Tubs	Showers Over Tubs	Kitchen Sinks	Laundry Trays	Separate Showers	
A	1	1	1	1	2	0	25
A	2	2	1	1	2	0	30
A	2	2	2	1	2	0	35
A	2	1	1	1	2	1	55
B	1	1	0	1	2	0	20
C	1	1	0	1	1	0	15

Note.—The quantity of hot water required per day is usually about 10 times the maximum hour requirement.

TABLE 8. HOT WATER REQUIREMENTS FOR HOTELS

CLASS	GALLONS		ADD FOR KITCHENS PER MEAL CAPACITY		ADD FOR LAUNDRY		
	Hot Water per H. W. Fixture per Day	Per H. W. Fixture per Maximum Hour	Per Day	Per Maximum Hour	Per Piece per Day	Per Washer per Day	Per Washer per Maximum Hour
High-class transient	85	6.8	3.0	1.0	1.0	1200	250
Medium-class transient	70	6.5	2.5	0.80	1.0	1000	200
Apartment hotels	50	5.0	2.0	0.60	1.0	1000	200

Note.—Instantaneous demand rate for laundry washers from 25 to 50 gal. per minute.

TABLE 9. HOT WATER REQUIREMENTS FOR OFFICE BUILDINGS

CLASS	HOT WATER PER HOT-WATER FIXTURE	
	Per Day	Per Maximum Hour
Having hot water in public toilets only	50	5.0
Having hot water in private offices as well as in public toilets	30	3.0
For self-closing hot-water fixtures deduct	40%	25%

TABLE 10. HOT WATER REQUIREMENTS FOR HOSPITALS

	HOT WATER	HOT WATER
	Per Patient	Per Fixture
Gallons used per average day	82	48
Gallons used per maximum day	127	65
Average maximum rate of flow for 15 min. in gallons per hour	11	7
Maximum rate of flow for 15 min. in gallons per hour	19	8

Note.—The above values are based on *Utility Demands of a Modern Hospital*, by Larson, Nelson and Rose. See JOURNAL, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, January 1928.

Note.—The hot water used is 25 per cent of total water requirements. The above requirements are for a hospital without a laundry.

fixtures can be taken from Tables 5 and 6. On the top story it will be necessary to use a 1½-in. branch to carry 60 gal. per minute with a pressure drop of 30 lb. but that at 30 ft. vertically from the supply, a 1¼-in. branch pipe will carry 60 gal. per minute; therefore 1¼-in. pipe could be selected for this branch. Assuming that the pressure drop in the main riser is 10 lb. per 100-ft. run and the pressure drop on the top story in the branch does not exceed 15 lb. in all and the static head for building 100 ft. as given in column 2 of Table 6 is 43.31 lb., making a total of 58.31 lb.; it will be seen that 75 lb. — 58.31 lb., which equals 16.69 lb., is the amount of pressure over and above that required, and that this pressure can be utilized to overcome the friction drop in the main feed line running from the source of supply to the base of the riser.

From Table 2 it is found that 240 gal. per minute will flow at the first story, and assuming that this water supply is to be carried in a main 300 ft. long, a 3½-in. supply would be necessary according to Table 5.

TABLE 11. WATER REQUIREMENTS FOR HOSPITALS[a]

	TOTAL WATER	TOTAL WATER USED EXCLUSIVE OF AMOUNT USED IN TOILETS, SLOP SINKS, SOFTENER FLUSHING AND REFRIGERATION COOLING		COLD WATER USED EXCLUSIVE OF AMOUNT USED IN TOILETS, SLOP SINKS, SOFTENER FLUSHING AND REFRIGERATION COOLING	
	Per Patient[b]	Per Fixture	Per Patient	Per Fixture	Per Patient
Gallons used per average day	366	77	275	104	193
Gallons used per maximum day	527	116	423	174	296
Average maximum rate of flow for 15 min. in gallons per hour	29	7	25	8	14
Maximum rate of flow for 15 min. in gallons per hour	50	12	44	16	30

[a] The values given are based on *Utility Demands of a Modern Hospital* by Larson, Nelson and Rose. See JOURNAL, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, January 1928. (No laundry included.)

[b] The items in this column, include water used for flushing softeners and refrigeration condenser.

Example: What pressure is required in the water supply main to give 15 lb. pressure at the uppermost fixture in a building where the riser is 100 ft. high and is located 75 ft. from the water main in a horizontal direction, when the other fixtures within the building are in use to their estimated average capacity?

The answer, according to Table 5, is found to be 75.8 lb. at the intersection of 100 ft. vertical height and 75 ft. horizontal run.

Note.—If only 10 lb. be required at the uppermost fixture, then 70.8 lb. would be the answer.

WHEN THE HOUSE TANK IS ON THE ROOF

If the tank is elevated above the highest fixture, similar computations will apply for branch connections and main risers except that the main riser will have its greatest diameter at the top. It will be seen that an elevation of 35 ft. or more will give the necessary 15 lb. pressure at the highest fixture and that the pressure drop may be made equal to the static head from the top fixtures down, or 40 lb. per 100.

HOT WATER SUPPLY

Tables 7, 8, 9 and 10 give the hot-water requirements for several kinds of buildings in terms of gallons per maximum hour and per day. Table 11 gives the total water requirements for hospitals.

Pipe sizes for hot-water systems may be calculated from the foregoing data on cold-water systems, using the same quantities for the gallons of hot water required per minute as is given for the cold water. It should be borne in mind that a column of hot water is lighter than one of cold water, amounting to about 2½ ft. per 100 ft. in the height of columns of equal weight. In case the cold water must first be fed down from roof tanks to heaters in the basement and then back up to the top-floor fixtures, the extra length of run must be taken into consideration. As a check on the total quantity of hot and cold water required per day, this is generally from two to three times the amount of hot water required and from 80 to 100 gal. per occupant of the building.

The return main for circulating systems may be the size of the most distant hot water flow main. It is obvious that no advantage will be gained by making the return any larger than this, but it is equally obvious that with very large circulating systems, it may be desirable upon occasion to make the most distant flow main larger than otherwise would be required, because of provision for the return circuit.

There are available mechanical circulation boosters with small electric motors and loosely-fitted propellers in the hot-water mains. These pumps will create a rapid and positive circulation of the water and are valuable especially in correcting existing sluggish systems.

CHAPTER 24

INSULATION FOR PIPES AND SURFACES

Heat Transfer Through Bare Pipe; Insulation for Hot Pipes and Surfaces; Insulation for Cold Pipes and Surfaces; Economic Thickness; Thickness to Prevent Pipe Sweating.

THE heat resistance of metallic pipes and surfaces is very small. Consequently, they should be adequately insulated to permit the steam or hot or cold liquids to be economically conveyed through them and without undue rise or drop in temperature.

HEAT LOSSES THROUGH BARE PIPE

Fig. 1 shows the loss in B.t.u. per square foot of bare pipe surface per hour per degree fahrenheit temperature difference for pipes of various diameters.

Table 1 gives the B.t.u. loss as well as the loss in dollars and cents and in pounds of coal per 100 lineal feet of bare pipe for temperatures up to 350 deg. fahr. Pounds of coal used are given per 100 lineal feet of pipe per month (assuming continuous use of the apparatus, 70 per cent boiler efficiency, and 13,000 B.t.u. per pound of coal). The *dollars* column represents the money value of the coal used per 100 lineal feet per month (assuming coal at $4.00 per ton and boiler room expense at $1.00 per ton).

The heat loss from bare pipes of various diameters up to 18 in. and at various temperatures can be calculated from the empirical equation:

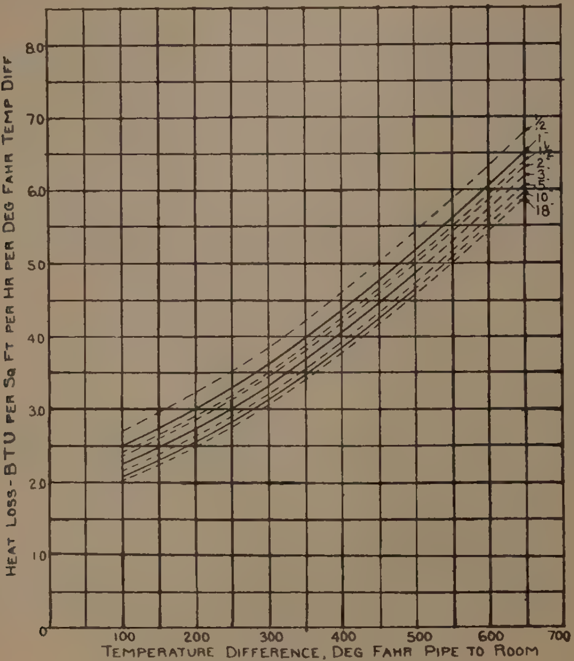
$$Q = 3320 \frac{77 + t_d - 103\,D^{0.11}}{103\,D^{0.11} - t_d + 1020}$$

where

Q = B.t.u. loss per hour per square foot of bare pipe surface.
D = outer diameter of pipe, in inches.
t_d = temperature difference between pipe surface and air, deg. fahr.

The loss of heat per unit area from flat surfaces varies greatly with the size and position of the heat-losing body. The loss from the surface in a horizontal position is entirely different for the same surface in a vertical position. Also, the loss is different for the same flat surface facing downward or upward. For these reasons a single equation or curve has not yet been obtained that will give accurately the heat loss from flat surfaces in various positions. However, until more experimental work has been conducted, it is suggested that the heat loss from flat bare iron surfaces be taken as equal to 95 per cent of the values given for the 18 in. pipe in Fig. 1.

In order to determine heat losses per linear foot of pipe from known losses per square foot, it is necessary to know the number of square feet area per linear foot of pipe. Table 2 gives these areas for various standard pipe sizes while Table 3 gives the area in square feet for flanges and fittings for various standard pipe sizes.



(R. H. Heilman, *Mech. Eng.*, Vol. 46 [1924], p. 593)

FIG. 1. BARE PIPE LOSS CURVES

INSULATION OF HOT WATER, LOW AND HIGH PRESSURE STEAM LINES

The conductivities, in B.t.u. per square foot per hour per inch thick per degree fahrenheit temperature difference between inner and outer surfaces of the insulation are given in Fig. 2 for various insulations. In this figure the conductivities are plotted as functions of the mean temperatures or the mean of the inner and outer surface temperatures of the insulations.

This method of plotting conductivities, enables one readily to calculate the heat loss through single or compound sections. It should be emphasized that in this figure, the conductivities given for the various insulations are the average values from a number of tests on each type of

TABLE 1. LOSSES FROM HORIZONTAL BARE IRON STEAM PIPES

From 100 lineal feet of pipe per month of 30 days with steam in pipes 24 hours per day. Coal at $4.00 per ton of 2000 lb.

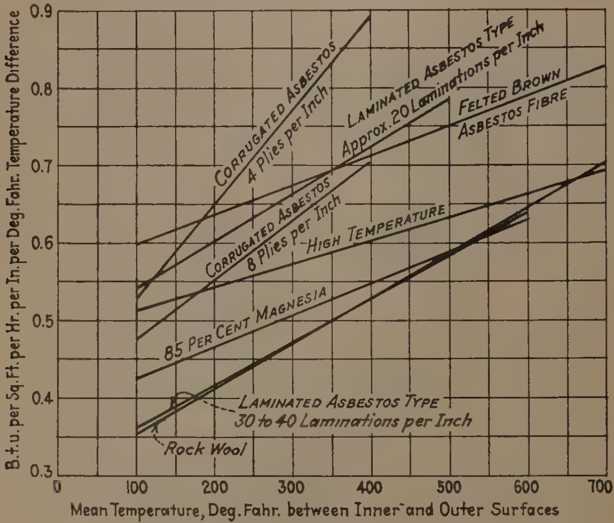
Pipe Size	GAGE PRESSURE TEMPERATURES																				
	Hot Water												10 Lbs.			80 Lbs.			120 Lbs.		
	120 Deg. Fahr.			150 Deg. Fahr.			180 Deg. Fahr.			210 Deg. Fahr.			239.4 Deg. Fahr.			324 Deg. Fahr.			350 Deg. Fahr.		
	Dollars Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Dollars Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Dols. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Dols. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Dols. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Dols. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.	Dols. Loss	Lbs. Coal	B.t.u. per Lineal Ft. per Deg. Fahr. Diff. per Hr.
½″	0.53	215	0.543	0.90	363	0.573	1.32	526	0.605	1.77	707	0.638	2.24	897	0.670	3.92	1566	0.779	4.51	1805	0.815
¾″	0.65	261	0.660	1.09	437	0.690	1.58	635	0.729	2.11	845	0.762	2.70	1083	0.809	4.74	1895	0.943	5.48	2190	0.990
1″	0.78	313	0.791	1.31	525	0.829	1.91	763	0.878	2.55	1020	0.920	3.26	1305	0.973	5.72	2290	1.14	6.25	2601	1.18
1¼″	0.97	388	0.979	1.61	646	1.02	2.36	947	1.087	3.19	1275	1.15	4.00	1610	1.20	7.14	2860	1.42	8.18	3280	1.48
1½″	1.08	432	1.09	1.82	728	1.15	2.65	1060	1.220	3.57	1430	1.29	4.54	1818	1.35	7.98	3190	1.58	9.28	3710	1.67
2″	1.32	530	1.34	2.21	886	1.40	3.24	1297	1.491	4.37	1750	1.58	5.36	2142	1.60	9.78	3910	1.94	11.37	4549	2.05
2½″	1.56	625	1.58	2.64	1056	1.67	3.86	1545	1.778	5.18	2075	1.87	6.65	2660	1.98	11.66	4660	2.32	13.66	5460	2.46
3″	1.86	744	1.88	3.15	1260	1.99	4.56	1824	2.100	6.12	2460	2.22	8.24	3292	2.46	13.88	5550	2.76	16.14	6450	2.91
3½″	2.11	843	2.13	3.54	1418	2.24	5.18	2070	2.380	6.95	2780	2.51	8.89	3554	2.65	15.82	6325	3.14	18.31	7322	3.30
4″	2.33	934	2.36	3.95	1580	2.50	5.78	2305	2.650	7.70	3080	2.78	9.87	3950	2.95	17.70	7075	3.52	25.50	8200	3.70
4½″	2.57	1030	2.60	4.35	1740	2.75	6.35	2540	2.920	8.53	3420	3.08	10.94	4370	3.26	19.48	7790	3.87	22.60	9025	4.07
5″	2.84	1135	2.87	4.77	1910	3.02	6.95	2780	3.200	9.36	3750	3.38	11.97	4790	3.57	21.25	8500	4.23	24.62	9850	4.45
6″	3.35	1342	3.39	5.62	2250	3.56	8.20	3280	3.775	11.10	4450	4.01	14.21	5680	4.24	25.30	10,110	5.02	29.30	11,720	5.29
7″	3.83	1533	3.87	6.40	2570	4.06	9.40	3760	4.325	12.70	5080	4.58	16.18	6470	4.82	29.10	11,640	5.78	33.70	13,480	6.09
8″	4.27	1710	4.32	7.20	2880	4.55	11.00	4398	5.050	14.24	5700	5.14	18.25	7300	5.45	32.60	13,030	6.45	37.65	15,050	6.84
9″	4.75	1900	4.80	8.00	3200	5.05	11.62	4650	5.350	15.80	6330	5.71	20.35	8130	6.07	36.25	14,500	7.21	42.10	16,840	7.60
10″	5.26	2100	5.32	8.86	3550	5.61	12.68	5065	5.925	17.55	7030	6.34	22.05	8820	6.58	40.20	16,100	8.01	46.70	18,690	8.44
12″	6.18	2475	6.25	10.46	4190	6.62	15.00	6000	6.995	20.65	8270	7.46	26.44	10,580	7.89	47.40	18,950	9.42	55.40	22,120	10.00
14″	6.74	2700	6.82	11.40	4570	7.22	16.60	6635	7.625	22.40	8980	8.10	28.90	11,560	8.62	52.00	20,800	10.34	60.50	24,200	10.92
16″	7.66	3065	7.74	12.95	5190	8.20	18.82	7525	8.650	25.50	10,200	9.20	32.80	13,120	9.79	58.76	23,500	11.70	68.40	27,320	12.34
18″	8.58	3440	8.68	14.53	5820	9.20	21.00	8400	9.650	28.60	11,450	10.33	36.10	14,460	10.80	65.40	26,150	13.00	76.50	30,570	13.80

In these tables coal has been figured at $4.00 per ton of 2000 lb.—13,000 B.t.u. per lb. of coal—labor, boiler room expense, etc., taken at $1.00 per ton, making total value of coal fired at $5.00 per ton. Boiler efficiency taken at 70 per cent. Air temperature 70 deg. fahr. Experimental data obtained at the *Mellon Institute.*

material, also that all variables due to differences in thickness, different pipe sizes, and different air conditions are eliminated.

The heat losses through any of the insulations shown in Fig. 2 for various thicknesses of covering and for any temperatures generally used in engineering practice can be obtained from Table 5 and Figs. 3, 4 and 5.

In these curves the unit loss through 1, 1½ and 2 in. thick covering is given for temperature differences up to 700 deg. fahr. The loss through other thicknesses of covering can be obtained from the curves by interpolation.



(R. H. Heilman, *Mech. Eng.*, Vol. 46 [1924], p. 593)

Fig. 2. Thermal Conductivity

Table 5 gives the factor by which the loss from the curves shown in Figs. 3 to 5 must be multiplied to give the loss through any of the coverings whose conductivity values are given in Fig. 2.

INSULATION FOR COLD SURFACES

Surfaces maintained at a low temperature should be insulated so as to retard the flow of heat from the outside into the low temperature area and to prevent the formation of condensation and of frost if the temperatures are low enough, as well as to prevent corrosion, induced by the presence of condensed moisture on metal surfaces.

Coverings are available commercially to meet varying temperature gradients. For example: The thickness of insulation for ice water is approximately 1½ in. if the temperature in the line is not lower than

TABLE 2. RADIATING SURFACE PER LINEAR FOOT OF PIPE

PIPE SIZE IN.	SURFACE SQ. FT.	PIPE SIZE IN.	SURFACE SQ. FT.	PIPE SIZE IN.	SURFACE SQ. FT.
½	0.22	2	0.622	5	1.456
¾	0.275	2½	0.753	6	1.734
1	0.344	3	0.917	8	2.257
1¼	0.435	3½	1.047	10	2.817
1½	0.498	4	1.178	12	3.338

25 deg. fahr.; the thickness of insulation for brine is approximately 2½ in., where the temperature ranges from 0 deg. to 25 deg. fahr.; and the thickness of insulation where the brine temperature ranges from −30 to 0 deg. fahr. is approximately 4 in.

The thermal conductivities of the materials commonly used for low temperature insulation for pipes and surfaces are given in Table 4.

In some cases, the prevention of condensation rather than the conservation of heat is the governing factor in determining the thickness of insulation required. Figs. 6 and 7 may be used for the determination of thickness of any material of known conductivity which should be used to prevent sweating on pipes and flat metallic surfaces. The curves in Fig. 7 have been calculated on the basis of using an insulating material which has a thermal conductivity of 0.3 B.t.u. per hour per square foot per degree fahrenheit per inch of thickness. The surface resistance used is based on results obtained on canvas covered surfaces. However, it has been found that the resistance for asphaltic and roofing surfaces is

TABLE 3. AREAS OF FLANGED FITTINGS, SQUARE FEET

NOMINAL PIPE SIZE I. D.	FLANGED COUPLING		90 DEG. ELL		LONG RADIUS ELL		TEE		CROSS	
	Standard	Extra Heavy	Standard	Extra Heavy	Standard	Extra Heavy	Standard	Extra Heavy	Standard	Extra Heavy
1″	0.320	0.438	0.795	1.015	0.892	1.083	1.235	1.575	1.622	2.07
1¼″	0.383	0.510	0.957	1.098	1.084	1.340	1.481	1.925	1.943	2.53
1½″	0.477	0.727	1.174	1.332	1.337	1.874	1.815	2.68	2.38	3.54
2″	0.672	0.848	1.65	2.01	1.84	2.16	2.54	3.09	3.32	4.06
2½″	0.841	1.107	2.09	2.57	2.32	2.76	3.21	4.05	4.19	5.17
3″	0.945	1.484	2.38	3.49	2.68	3.74	3.66	5.33	4.77	6.95
3½″	1.122	1.644	2.98	3.96	3.28	4.28	4.48	6.04	5.83	7.89
4″	1.344	1.914	3.53	4.64	3.96	4.99	5.41	7.07	7.03	9.24
4½″	1.474	2.04	3.95	5.02	4.43	5.46	6.07	7.72	7.87	10.07
5″	1.622	2.18	4.44	5.47	5.00	6.02	6.81	8.52	8.82	10.97
6″	1.82	2.78	5.13	6.99	5.99	7.76	7.84	10.64	10.08	13.75
7″	2.17	3.46	6.17	8.62	7.38	9.73	9.37	12.33	12.00	16.83
8″	2.41	3.77	6.98	9.76	8.56	11.09	10.55	14.74	13.44	18.97
9″	3.00	4.44	8.71	11.44	10.57	13.17	13.18	17.23	16.78	22.10
10″	3.43	5.20	10.18	13.58	12.35	15.60	15.41	20.41	19.58	26.26
12″	4.41	6.71	13.08	17.73	16.35	18.76	19.67	26.65	24.87	34.11
14″ O. D.	5.39	8.30	16.38	22.31	20.17	25.70	24.81	33.63	31.48	43.15
15″ O. D.	6.18	9.52	18.50	25.28	22.92	29.34	27.91	38.04	35.48	48.79
16″ O. D.	6.69	10.05	20.17	27.18	25.41	31.73	30.32	40.94	38.34	52.35

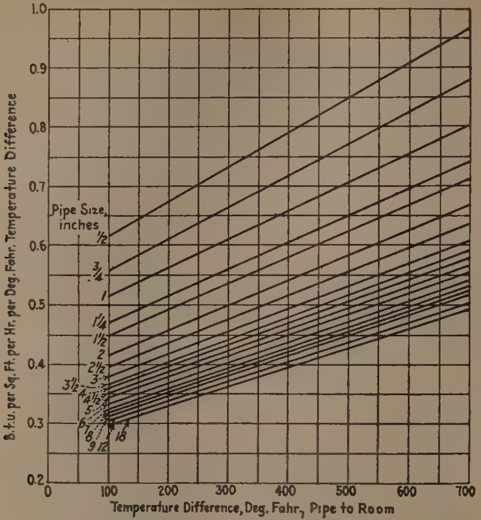


Fig. 3. Heat Loss through 1 in. thick Covering

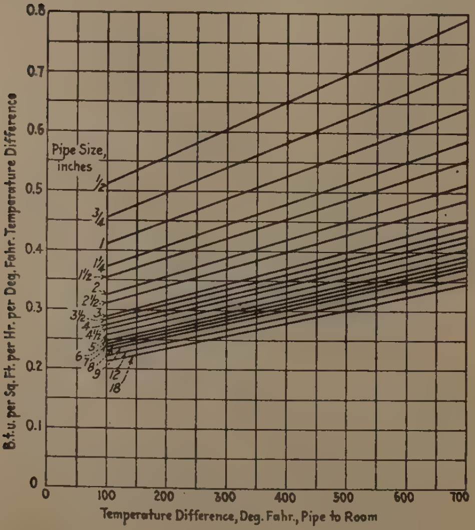


Fig. 4. Heat Loss through 1½ in. thick Covering

practically the same as for canvas surfaces so that the curves given may be followed with no alteration on account of the surfaces commonly used. (See discussion of surface transfer of heat in Chapter 2, page 18).

To determine the thickness of insulation necessary to prevent sweating for coverings having conductivity values differing from the value of 0.3 used in computing the curves, increase or decrease the values taken from

TABLE 4. VALUES OF *k* CORRESPONDING TO COMMONLY USED COVERINGS

	k	PER CENT VARIATION FROM $k = 0.3$
Hair Felt	0.246	−18%
Keystone Hair	0.27	−10%
Wood Felt	0.36	+20%
Cork, 6.9 lb. per cubic foot	0.27	−10%
Cork, 9.7 lb. per cubic foot	0.30	0%
Cork, 16 lb. per cubic foot	0.35	+17%

TABLE 5. PIPE-COVERING FACTORS

TYPE OF COVERING	TEMPERATURE DIFFERENCE, PIPE TO AIR, DEG. FAHR.						
	100	200	300	400	500	600	700
85% Magnesia	1.234	1.184	1.148	1.111	1.082	1.051	1.025
Laminated Asbestos Type. Approx. 20 laminations per inch	1.515	1.474	1.441	1.409	1.383	1.360	1.345
Laminated Asbestos Type. Approx. 30 to 40 laminations per inch	1.022	1.019	1.016	1.013	1.010	1.007	1.005
High Temperature	1.438	1.358	1.292	1.233	1.190	1.147	1.109
Felted Brown Asbestos Fibre	1.665	1.577	1.505	1.436	1.387	1.340	1.300
Rock Wool	1.058	1.045	1.035	1.022	1.020	1.014	1.010
Corrugated Asbestos, 8 plies per inch	1.349	1.340	1.333	1.323	....	....	....
Corrugated Asbestos, 4 plies per inch	1.520	1.550	1.580	1.605	....	....	....

TABLE 6. THICKNESSES OF INSULATION ORDINARILY USED

STEAM PRESSURES (LB. GAGE)	STEAM TEMPERATURES (DEG. FAHR.)	THICKNESS OF INSULATION		
		Pipe larger than 4 in.	Pipes 2 in. to 4 in.	Pipes ½ in. to 1½ in.
0 to 25	212 to 267	1 in.	1 in.	1 in.
25 to 100	267 to 338	1½ in.	1 in.	1 in.
100 to 200	338 to 388	2 in.	1½ in.	1 in.
Higher Pressure or Superheat	388 to 500	2½ in.	2 in.	1½ in.
Higher Pressure or Superheat	500 to 600	3 in.	2½ in.	2 in.

Example: Determine the heat flow in B.t.u. per hour per square foot of pipe surface through a magnesia covering 1 in. thick on a 4 in. pipe.

Solution: The temperature of the pipe is 270 deg. fahr. and the room temperature, 70 deg. fahr. The loss through a covering 1 in. thick on a 4 in. pipe at 200 deg. temperature difference from Fig. 5 = 0.395; the factor for magnesia at 200 deg. temperature difference from Table 5 = 1.184; then the heat loss through the magnesia covering = 0.395 × 1.184 × 200 = 93.5 B.t.u. per square foot of pipe surface per hour.

the curves by the percentages indicated in the last column of Table 4. These percentages will give values approximately correct.

In Fig. 7: $\begin{cases} t^o = \text{temperature of air on warm side of insulation.} \\ t''' = \text{temperature of the medium on cold side of insulation.} \end{cases}$

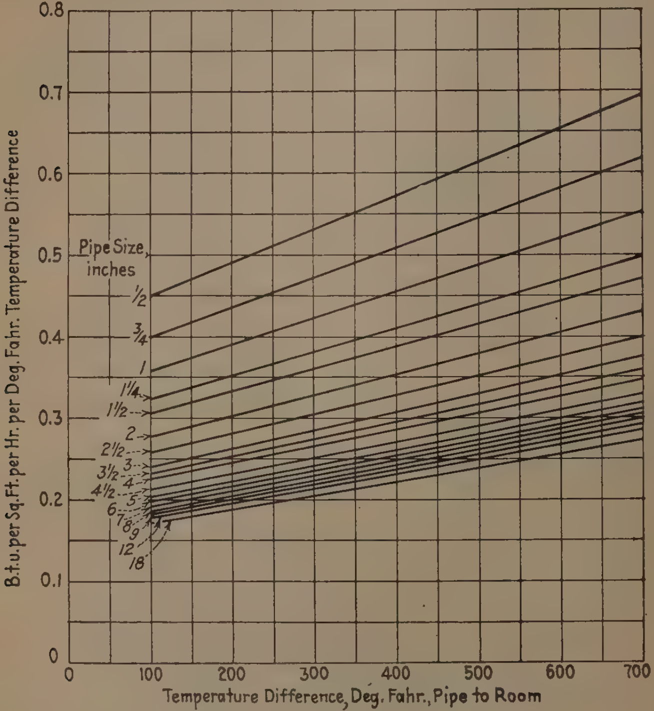


FIG. 5. HEAT LOSS THROUGH 2 IN. THICK COVERING

EFFECT OF AIR VELOCITY ON SURFACE LOSSES

The rate of heat loss from a surface maintained at constant temperature is greatly increased by air circulation over the surface. Fig. 8 is based on Langmuir's equations (*Trans. Am. Electro-Chem. Soc.*, Vol. 23). Other investigators have shown even greater increases in rates of heat loss from bare surfaces due to air velocity.

In the case of well-insulated surfaces the increases in losses due to air velocity are very small as compared with increases shown above for bare surfaces, because of the fact that air flowing over the surface of the insulation can increase only the rate of heat transfer from surface to air,

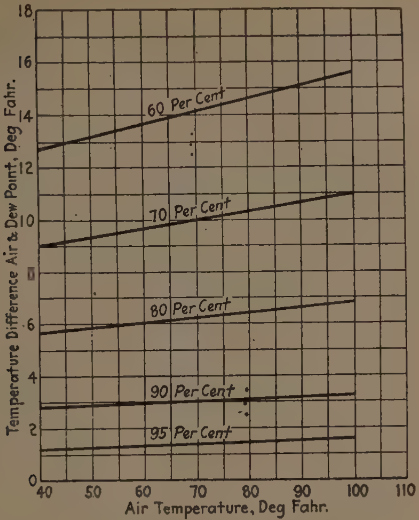
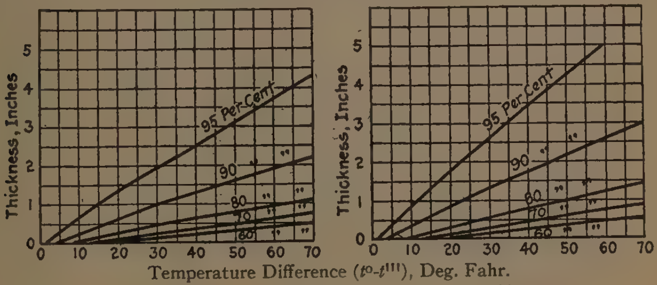
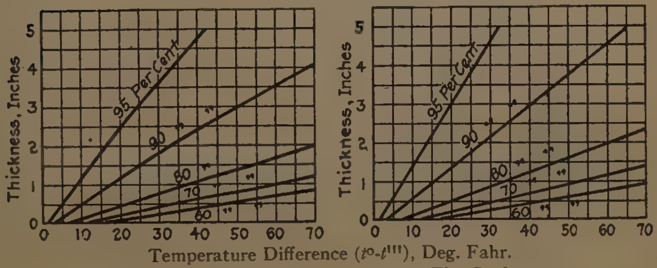


Fig. 6. Temperature Difference between Air and Dew Points at Different Relative Humidities



1-in Pipe

3-in. Pipe

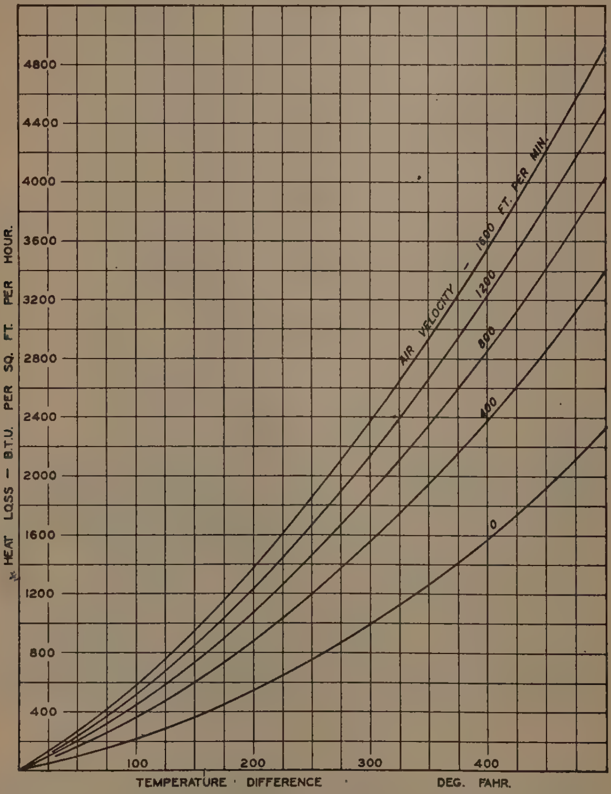


10-in. Pipe

Flat Surface

Fig. 7. Thickness of Insulation to Prevent Sweating

and cannot change the internal resistance to heat flow inherent in the insulation itself. The maximum increase in loss due to air velocity ranges from about 30 per cent in the case of 1 in. thick insulation, to about

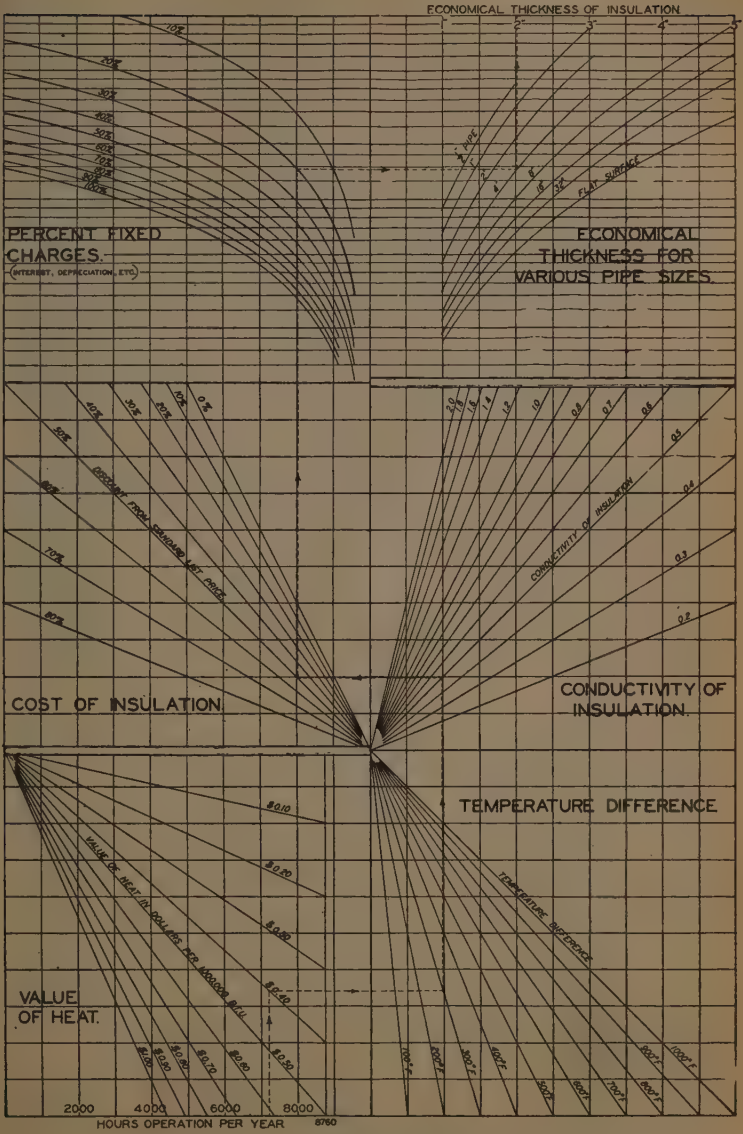


(L. B. McMillan, *Iron and Steel Engineer, July 1925.*)

Fig. 8. Heat Losses from Surfaces Exposed to Various Air Velocities

10 per cent in the case of 3 in. thick insulation, provided that the insulation is thoroughly sealed so that air can flow only over the surface.

If the conditions are such that the air may circulate through cracks and crevices in the insulation, the increases may be far greater than those given above. Therefore, it is essential that insulation be sealed as tightly as possible. Pipe insulation out-of-doors should be provided with a weather-proof jacket, and other outdoor insulation should be thoroughly weather-proofed.



(L. B. McMillan, *Proc. National Dist. Heating Ass'n.*, Vol. 18, p. 131.)

FIG. 9. CHART FOR DETERMINING ECONOMICAL THICKNESS OF INSULATION

ECONOMIC THICKNESS OF PIPE INSULATION

Table 6 shows the thicknesses of insulation which ordinarily are used for various temperature conditions. Where a thorough analysis of economic thickness is desired, this may be accomplished through the use of the chart, Fig. 9.

The dotted line on the chart illustrates its use in solving a typical example. In order to use the chart, start at the lower left hand corner and proceed to the right to a point representing the given number of hours of operation per year; then proceed vertically to the line representing the given value of heat; thence horizontally, to the right, to the line representing the given temperature difference; thence vertically to the line representing the conductivity of the given material; thence horizontally, to the left, to the line representing the given discount on that material; thence vertically to the curve representing the required per cent return on the investment; thence horizontally, to the left, to the curve representing the given pipe size; thence vertically to the scale at the top of the sheet where the economical thickness may be read off directly. The dotted line on the chart illustrates its use in solving a typical example.

It is impossible to determine accurately the economic thickness of insulation to use for an underground installation owing to the many variables which are present such as depth of line, conductivity of ground, moisture conditions, etc. However, it is considered good practice to insulate underground lines with approximately ½ in. less thickness of insulation than for above ground installations under similar operating conditions.

It is necessary to keep the insulation absolutely dry if the efficiency is to be maintained, therefore, precautions should be taken thoroughly to weather-proof the insulation and to provide a drainage system for the water which may get into the conduit.

HEAT LOSSES FROM BARE FITTINGS

Very often, even where pipes are thoroughly insulated, flanges and fittings are left bare due to the belief that the losses from these parts are not large. However, the fact that a pair of 10 in. standard flanges having an area of 3.43 sq. ft. would lose, at 100 lb. steam pressure, an amount of heat equivalent to more than a ton of coal per year shows the necessity for insulating such surfaces. Table 3 shows the areas of both standard and extra heavy flanged fittings including the accompanying flanges bolted to the fittings.

CHAPTER 25

DISTRICT HEATING

Typical Service Connections; Control Devices; Underground Distribution Systems; Expansion and Contraction; Conduits and Tunnels; Insulation; Steam Requirements for Different Types of Buildings.

A GREAT deal of the information in this section will apply not only to the public utilities generally classed as district heating systems, but also to those institutional groups supplied from a central source, and perhaps better classified as central heating systems.

SERVICE CONNECTION METHODS

The practice of two companies in connecting the customer's premises with the street system are shown in accompanying sketches. Figs. 1 and 2 show the methods employed by a Boston utility for cooling condensate of customer's steam systems before discharging the condensate to the meter. Similar requirements hold where customers purchase steam by flow meter. In the latter case, however, the company does not insist that the customer meet the requirements completely as any loss in metering is borne by the customer. A vacuum or condensation return pump may be attached to these systems.

Fig. 3 shows a typical installation for service from the system of a New York utility. The practice followed by utilities in other localities may be found in the Handbook or the Proceedings of the *National District Heating Association.*

CONTROL OF STEAM SUPPLY

Because radiation for a building must provide for maximum load conditions, variable weather in many localities brings the problem of variable steam demand from the various heating elements in the building. This condition may be controlled by hand method or by any one of the systems of automatic heat control described in Chapter 17. Another form of regulation, known as the time-limit control, is sometimes employed for regulating the steam supply from the central station main to the building.

Such a control provides an intermittent supply of steam to the radiation either throughout the 24 hours of the day or during the daytime hours only. The setting of a switch may provide no service, continuous service, or periodic service. For the latter, by means of several intermittent settings, steam will be supplied during each period in increments of a certain number of minutes for each successive setting of the switch, steam being shut off during the balance of the period. These settings

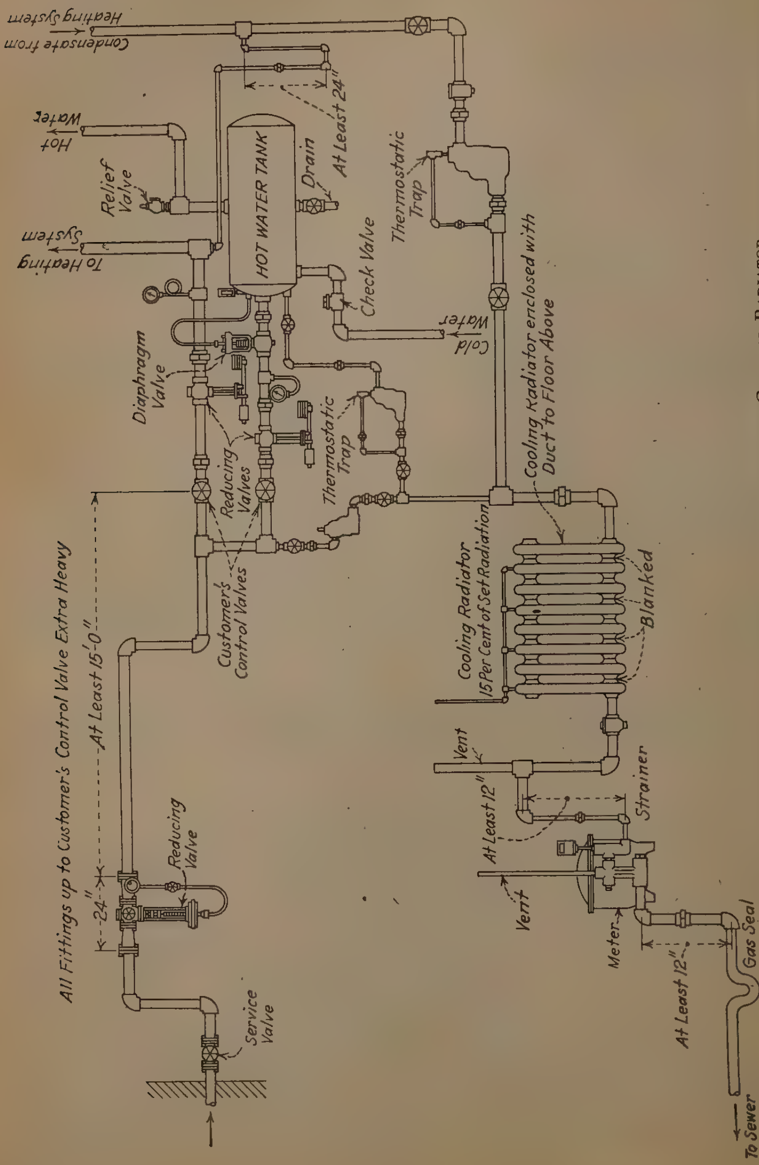


FIG. 1. STEAM SERVICE AND METER CONNECTIONS WITH COOLING RADIATOR

afford from 15 to 80 per cent of that maximum heating effect, required on days of zero temperature.

A night switch with a variety of settings, may be adjusted so as to maintain throughout the night the intermittent supply called for by the day switch setting, or may be set to interrupt the operation of the day switch and entirely cut off the supply of steam to the radiation at night during certain hours which are selected by the operating engineer.

A morning service switch may operate independently of the day and night switches to supply full steam service to the radiation during the early morning hours, 6.00 A.M. to 9.00 A.M., or afford an excess heat supply when desired by the operator.

Still another form of control regulates the pressure in the mains leaving the boiler plants to correspond with the changes in local factors.

In general practice, the size of a pipe line is fixed so that steam can be delivered to the system at full rated boiler pressure. With a maximum load, the pressure drop in the line will be such that a fixed pressure can be held at a distant point due to definite requirements of the customer. This maximum load is generally fixed by future requirements that may not be reached for years; also the daily and hourly load may vary materially, or the pressure requirements fixing the design may vary at certain periods. Rather than carry full boiler pressure on the system with its corresponding line loss under varying loads, considerable saving can be made by installing one or more pressure-reducing valves in the boiler plant for holding the pressure at a point to correspond with the actual load requirements. In institutional heating these pressure-reducing valves make it possible to reduce the night pressure materially, thereby making a decided saving in coal. Where the load requirements vary considerably, a bank of reducing valves is often installed in multiple, so that the valve in use will be working very close to its rating.

At the present time, the tendency is to distribute at as high a steam pressure as possible, without unduly increasing the cost of the line construction. With standard weight pipe and welded joints, there is no reason why the line should not carry at least 200 lb. pressure at maximum load. With these higher pressures the lines can be kept small, decreasing the investment cost and corresponding line losses.

The reduction in pressure at the boiler plant, together with a considerable drop in the line, will produce a superheating of the steam so that the superheating will balance the line loss and this will make very little, if any, trap drip discharge, thereby eliminating water hammer. Too strong emphasis cannot be placed on the idea of having the distributing lines the right size rather than excessive.

The pipe line can be designed for any grade, but all low points should be drained through traps, discharging to the sewer or to return lines.

PIPE LINE EXPANSION

In laying out a pipe line the expansion should be actually determined for each run, and adequate provision should be made for it.

Two methods are in use for taking care of expansion, (1) by some form of expansion joint, and (2) by some form of offset or bend.

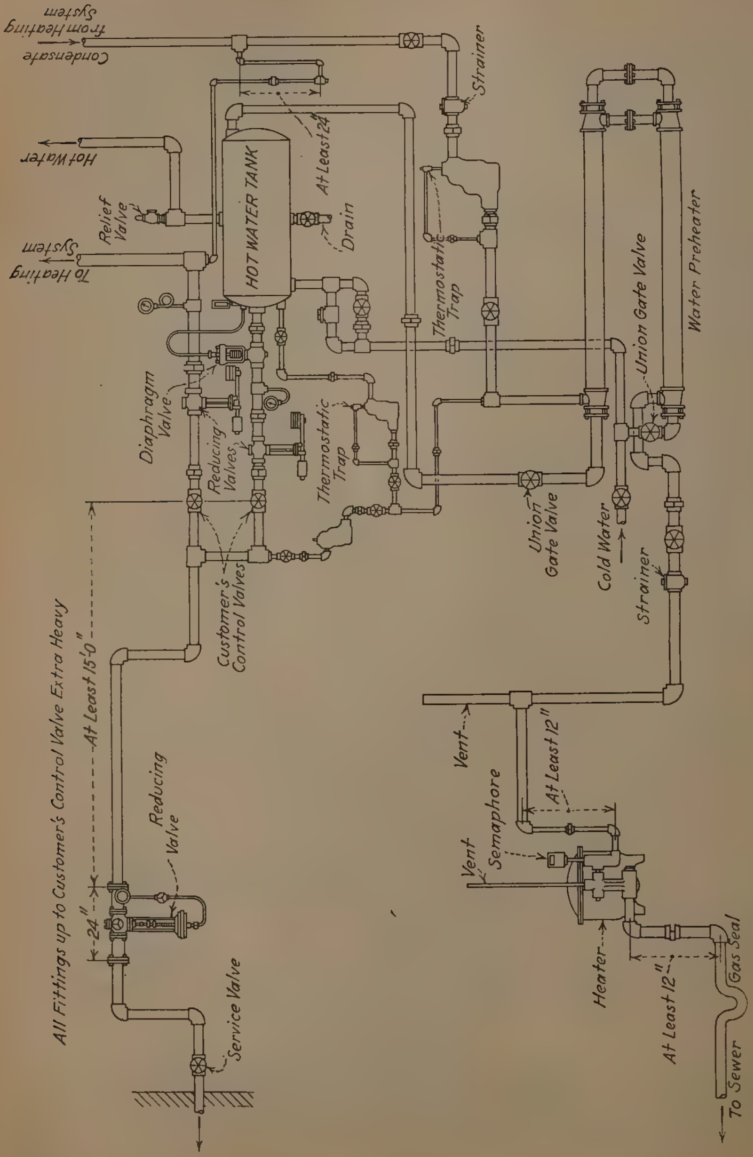


Fig. 2. Steam Service and Meter Connections with Water Preheater

Table 1 shows the expansion in 100 ft. of pipe at various temperatures. The expansion of any length of pipe is determined by taking the difference in expansion at minimum and maximum temperatures and dividing by 100 to arrive at the expansion per foot, then multiplying by the number of feet of pipe for which expansion is to be figured.

Table 1. Expansion of Pipe in Inches per 100 Ft.

Temperature Deg. Fahr.	Wrought Iron or Steel	Cast Iron	Copper and Brass
0	0.00	0.00	0.00
10	0.08	0.05	0.13
20	0.15	0.10	0.25
30	0.23	0.15	0.35
40	0.30	0.25	0.45
50	0.38	0.36	0.57
100	0.76	0.72	1.14
150	1.15	1.10	1.75
200	1.57	1.50	2.38
250	1.99	1.90	3.02
300	2.47	2.35	3.74
350	2.94	2.80	4.45
400	3.46	3.30	5.24

Table 2. Length of Expansion Offsets and Bends for Proper Expansion of Pipe

Total Expansion in Inches[a]	Feet of Pipe and Offset or U-Bend for different Diameters of Pipe									
	2"	3"	4"	5"	6"	8"	10"	12"	14"	16"
1	11	13	15	17	19	21	23	25	27	30
2	15	18	21	23	26	29	32	35	38	42
3	18	22	26	29	32	36	40	43	48	52
4	21	26	30	34	37	42	47	50	56	58
5	24	30	34	38	41	47	53	57	63	65
6	27	33	37	41	45	52	58	63	69	71
7	30	36	40	44	48	56	62	68	74	----
8	32	39	43	47	52	60	66	72	----	----

[a] This column shows the total expansion the offset will take care of without a cold strain. In general these amounts can be increased 40 per cent which increase can be taken up in cold strain of the pipe on being made up.

The length of pipe in the expansion piece should be the same whether in the form of a single right-angle offset or double offset or U-Bend.

The lengths of arms figured for 12,000 lb. per square inch tension for wrought iron pipe. If steel pipe is used this is good for 16,000 lb. per inch so that the arm will take care of ⅓ more expansion.

In the installation of transmission lines it is frequently the practice to figure on an installation temperature of 70 deg. fahr. and to compensate for about 40 per cent of the total expansion by means of a cold strain put in the line at the time of installation. This allows for only 60 per cent of all expansion to be taken care of by expansion joints, offsets or bends.

Table 2 gives the length of pipe that should be made up to provide for the expansion. In general the arms should be made up with pipe bends which can be welded into one continuous length.

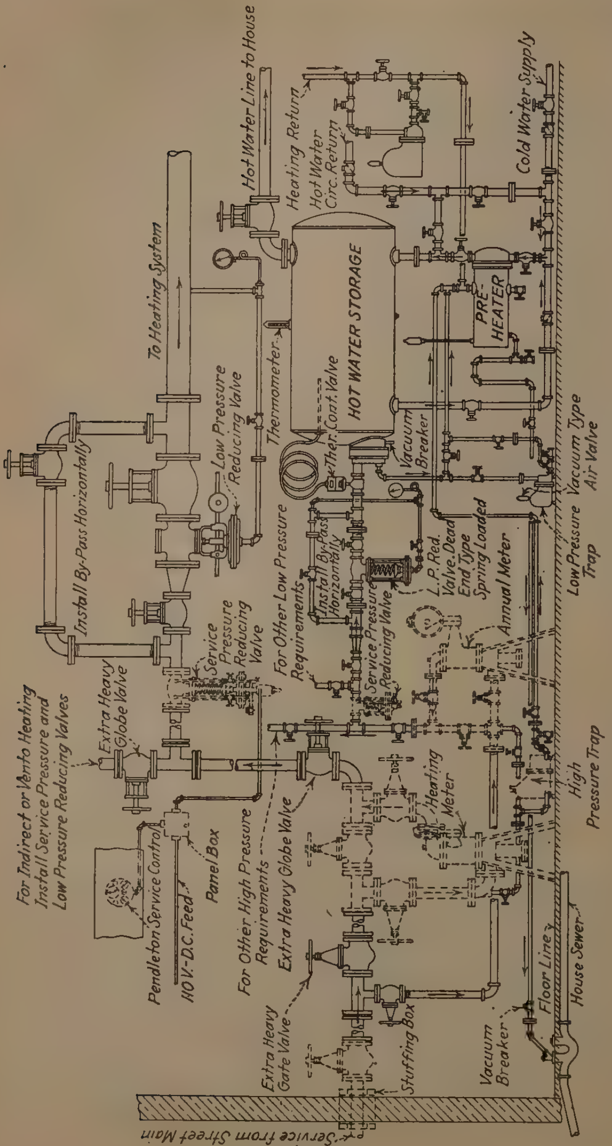


FIG. 3. TYPICAL SERVICE INSTALLATION

TABLE 3. CAPACITY OF RETURNS FOR UNDERGROUND DISTRIBUTION SYSTEMS IN POUNDS OF CONDENSATE PER HOUR

Size[a] of Pipe In.	Pitch of Pipe per 100 Ft.						
	6"	1'	2'	3'	5'	10'	20'
1	448	998	1890	2240	3490	5490	7490
1¼	1740	2490	3990	4880	6480	9480	13500
1½	2700	4190	5740	7480	9480	14500	20900
2	4980	7380	10700	13900	16900	24900	36900
3	13900	22500	30900	37400	50400	74800	105000
4	30900	44800	64800	79700	105000	154000	229000
5	54800	79800	120000	144800	195000	294000	418000
6	90000	138000	187000	237000	312000	449000	....
8	190000	277000	404000	508000	660000	938000	....
10	344000	498000	724000	900000	1190000	....	....
12	555000	798000	1148000	1499000	1990000	....	....

[a] Size of pipe should be increased if same carries any steam.

TABLE 4. STEAM REQUIREMENTS OF BUILDINGS FROM OUTSIDE MAINS IN POUNDS OF STEAM PER HOUR

Sq. Ft. Radiation	Steam Pressure of Service Main Lb. Gage							
	0	10	20	60	100	140	180	200
200	61.8	61.2	60.8	59.8	59.4	59.2	59.0	58.8
400	123.6	122.5	121.6	119.6	118.8	118.4	118.0	118.0
500	154.5	153	152	149.5	148.4	148	147.5	147
750	232	230	228	224	223	222	221	220
1000	309	306	304	299	297	296	295	294
2500	774	765	760	747	743	740	737	735
5000	1545	1530	1520	1495	1485	1480	1475	1470
7500	2320	2300	2280	2240	2230	2220	2210	2200
10000	3090	3060	3040	2990	2970	2960	2950	2940
12500	3865	3820	3800	3740	3720	3700	3690	3680
15000	4640	4590	4560	4480	4460	4440	4420	4410
20000	6180	6120	6080	5980	5940	5920	5900	5880
25000	7740	7650	7600	7470	7430	7400	7375	7350
30000	9290	9180	9120	8970	8910	8890	8850	8830
40000	12380	12250	12160	11960	11880	11840	11800	11780
50000	15450	15300	15200	14950	14850	14800	14740	14700
75000	23200	22800	22800	22400	22300	22200	22100	22000
100000	30900	30600	30400	29900	29700	29600	29500	29400
125000	38650	38300	38000	37400	37200	37000	36900	36800
150000	46400	45900	45600	44800	44600	44400	44250	44100
175000	54200	53600	53200	52300	52000	51800	51600	51400
200000	61800	61200	60800	59800	59400	59200	59000	58900

Each square foot of radiation transmits 250 B.t.u. per hour.

Table for steam entering buildings at stated pressures then reduced to required amount and condensed in radiator to water at 212 deg. fahr. 0 pressure. The above table also allows 20 per cent for piping loss in the building.

The offset lengths which are required for expansion in the case of wrought iron pipe may also be used for brass pipes, using in each case the actual amount of expansion in the piping.

CAPACITY OF RETURNS WITH VARIOUS GRADES

In general return lines when installed follow the contour of the land, and Table 3 gives sizes of return pipes for various grades. It is evident that at points where the grade is great, smaller pipes can be installed.

Table 4 gives the number of pounds of steam condensed to water for various steam pressures which can be used in determining the size of steam main or return line.

CAPACITY OF SUPPLY MAINS

Table 5 gives the capacity of various sizes of pipes under various steam pressures, based on a velocity of 10,000 ft. per minute. The pipe loss will not vary under other velocities. For other velocities, at the same pressure drop, the capacity may be determined by dividing by 10,000 and multiplying by the actual velocity.

Present practice in the design of underground lines is towards higher velocities, and 10,000 ft. per minute may be considered as a minimum. Velocities as high as 35,000 ft. per minute are becoming quite common. As an example, at a velocity of 35,000 ft. per minute, the capacities would be three and one-half times the values given in the table. In assuming the higher velocities, the corresponding pressure drop should be checked.

As already stated, with a maximum load, the pressure drop in a line will be such that a fixed pressure can be held at a distant point to meet definite requirements of a customer. For this reason, the practice has been quite well established among district heating companies for using pressure drop as the determining factor for fixing pipe sizes in order to give proper service at the end of any line. Following this practice velocities ranging from 25,000 to 50,000 ft. per minute are in use.

The formula generally accepted for the flow of steam in pipes is that using Babcock's constant of $K = 0.0027$. Table 6, derived from this formula, is taken from *Steam*, and gives the amount of steam passing per minute that will flow through straight smooth pipes having a length of 240 diameters, for various initial pressures with 1 lb. difference between the initial and final pressures.

To apply this table for other lengths of pipe and pressure losses than those assumed, let L = the length and d the diameter of the pipe, both in inches; l the loss in pounds; Q the weight under the conditions assumed in the table; and Q_1 the weight for the changed conditions.

For any length of pipe, if the weight of steam passing is the same as given in the table, the loss will be:

$$l = \frac{L}{240d}$$

If the pipe length is the same as assumed in the table, but the loss is different, the quantity of steam passing per minute will be:

$$Q_1 = Ql^{\frac{1}{2}}$$

For any assumed pipe length and loss of pressure, the weight will be:

$$Q_1 = Q\left(\frac{240dl}{L}\right)^{\frac{1}{2}}$$

Table 5. Pipe Sizes for Underground Supply Mains Based on a Velocity of 10,000 Ft. per Minute

Gage Pressure Lb.	Lb. Steam per Minute	Total B.t.u. above 200 Deg. Fahr. per Hr.	Pipe Loss B.t.u. per Hour, per Ft. Length		Lb. Steam Condensed per Hour per Ft. Length
			Bare	Covered (10% of Bare)	
		1 in. Pipe			
0	2.23	131,100	116	11.6	0.0119
10	3.65	217,200	143	14.3	0.015
20	4.98	298,200	168	16.8	0.0179
40	7.68	461,400	206	20.6	0.0224
60	10.3	627,000	236	23.6	0.0262
80	12.8	780,000	260	26.0	0.0292
100	15.3	936,000	284	28.4	0.0322
120	18.1	1,110,000	304	30.4	0.0349
140	20.6	1,272,000	322	32.2	0.0374
160	23.0	1,416,000	337	33.7	0.0395
180	26.0	1,608,000	355	35.5	0.0420
200	28.5	1,764,000	373	37.3	0.0445
		2 in. Pipe			
0	8.70	512,400	209	20.9	0.0216
10	14.2	846,000	258	25.8	0.0270
20	19.4	1,158,000	306	30.6	0.0327
40	29.8	1,794,000	372	37.2	0.0406
60	40.0	2,436,000	426	42.6	0.0472
80	49.7	3,030,000	471	47.1	0.0529
100	59.8	3,660,000	513	51.3	0.0582
120	70.5	4,338,000	548	54.8	0.0631
140	80.4	4,950,000	582	58.2	0.0675
160	89.6	5,520,000	608	60.8	0.0714
180	101.0	6,240,000	641	64.1	0.0760
200	111.0	6,888,000	674	67.4	0.0804
		3 in. Pipe			
0	19.2	1,129,200	309	30.9	0.0319
10	31.3	1,860,000	380	38	0.0399
20	42.8	2,562,000	451	45	0.0480
40	65.5	3,588,000	549	55	0.0600
60	87.5	5,280,000	628	63	0.0693
80	108	6,588,000	694	69	0.0775
100	130	7,980,000	756	76	0.0864
120	153	9,420,000	809	81	0.0931
140	174	10,740,000	857	86	0.0999
160	194	11,940,000	897	90	0.1058
180	220	13,560,000	945	94	0.1110
200	240	14,880,000	993	99	0.1180
		4 in. Pipe			
0	33.0	1,944,000	397	39.7	0.0404
10	54.0	3,210,000	489	48.9	0.0514
20	73.8	4,422,000	579	57.9	0.0617
40	113	6,840,000	705	70.5	0.0769
60	153	9,300,000	806	80.6	0.0895
80	189	11,520,000	891	89.1	0.1000
100	227	13,920,000	971	97.1	0.110
120	268	16,440,000	1039	103.9	0.119
140	305	18,780,000	1101	110.1	0.128
160	340	21,000,000	1152	115.2	0.135
180	384	23,760,000	1214	121.4	0.144
200	420	25,440,000	1275	127.5	0.152

TABLE 5. PIPE SIZES FOR UNDERGROUND SUPPLY MAINS BASED ON A VELOCITY OF 10,000 FT. PER MINUTE—(Continued)

GAGE PRESSURE LB.	LB. STEAM PER MINUTE	TOTAL B.T.U. ABOVE 200 DEG. FAHR. PER HR.	PIPE LOSS B.T.U. PER HOUR, PER FT. LENGTH		LB. STEAM CONDENSED PER HOUR PER FT. LENGTH
			Bare	Covered (10% of Bare)	
6 in. Pipe					
0	74.6	4,504,000	585	58.5	0.0604
10	122	7,260,000	719	71.9	0.0755
20	167	10,020,000	852	85.2	0.0918
40	256	15,360,000	1037	104	0.1135
60	345	20,880,000	1186	119	0.1320
80	427	26,040,000	1311	131	0.1470
100	514	31,440,000	1428	143	0.1630
120	606	37,260,000	1528	153	0.1760
140	690	42,480,000	1620	162	0.1880
160	770	47,400,000	1694	169	0.1980
180	870	53,700,000	1785	178	0.2110
200	950	58,800,000	1872	187	0.2230
8 in. Pipe					
0	134	7,980,000	760.7	76.1	0.0785
10	218	12,960,000	936.7	93.7	0.0985
20	298	17,940,000	1109.5	110.9	0.118
40	458	27,540,000	1351	135.1	0.147
60	617	37,560,000	1543	154.3	0.171
80	765	46,680,000	1707	170.7	0.191
100	917	56,160,000	1859	185.9	0.212
120	1080	66,480,000	1988	198.8	0.229
140	1230	75,300,000	2107	210.7	0.244
160	1375	84,600,000	2207	220.7	0.258
180	1550	95,400,000	2325	232.5	0.275
200	1700	105,600,000	2443	244.3	0.291
10 in. Pipe					
0	211	12,420,000	949	94.9	0.0978
10	345	19,520,000	1170	117.0	0.1230
20	474	28,380,000	1384	138.4	0.1480
40	730	43,860,000	1685	168.5	0.1840
60	983	59,760,000	1927	192.7	0.2130
80	1210	73,800,000	2132	213.2	0.2390
100	1455	89,100,000	2322	232.2	0.264
120	1670	102,600,000	2486	248.6	0.286
140	1960	120,600,000	2635	263.5	0.306
160	2180	134,400,000	2755	275.5	0.323
180	2470	152,400,000	2903	290.3	0.343
200	2700	166,800,000	3051	305.1	0.364
12 in. Pipe					
0	297	17,460,000	1125	112.5	0.116
10	485	28,860,000	1387	138.7	0.146
20	664	39,900,000	1641	164.1	0.175
40	1020	62,100,000	1999	199.9	0.218
60	1372	83,400,000	2240	224.0	0.248
80	1700	103,800,000	2529	252.9	0.284
100	2040	124,800,000	2753	275.3	0.314
120	2410	148,200,000	2945	294.5	0.340
140	2750	169,200,000	3121	312.1	0.362
160	3060	182,400,000	3266	326.6	0.383
180	3460	213,600,000	3440	344.0	0.406
200	3800	235,200,000	3616	361.6	0.430

Example: Find the weight of steam at 100 lb. initial gage pressure, which will pass through a 6 in. pipe 720 ft. long with a pressure drop of 4 lb.

Under the conditions assumed in the table, 287 lb. would flow per minute; hence, $Q = 287$ and

$$Q_1 = 287\left(\frac{240 \times 6 \times 4}{720 \times 12}\right)^{1/2} = 234 \text{ lb.}$$

TABLE 6. FLOW OF STEAM THROUGH PIPES

LENGTH OF PIPE = 240 DIAMETERS

INITIAL GAGE PRESS., POUNDS PER SQ. IN.	DIAMETER OF PIPE IN INCHES														Density[a]
	¾	1.0	1¼	2.0	2½	3.0	4.0	5.0	6.0	8.0	10.0	12.0	15.0	18.0	
	WEIGHT OF STEAM PER MINUTE IN POUNDS WITH ONE POUND LOSS IN PRESSURE														
1	1.13	2.04	5.49	9.85	14.8	24.4	45.0	74.2	105	202	329	482	771	1127	0.0385
10	1.39	2.54	6.82	12.3	18.5	30.3	55.9	92.3	138	248	409	599	958	1404	0.0595
20	1.63	2.98	8.02	14.4	21.9	35.6	65.7	108	163	295	481	705	1128	1645	0.0823
30	1.84	3.37	9.07	16.2	24.5	40.2	74.1	122	183	333	542	795	1272	1858	0.1047
40	2.03	3.71	9.95	17.9	26.9	44.2	81.6	135	202	366	596	874	1388	2089	0.1267
50	2.19	4.02	10.8	19.4	29.2	47.9	88.3	146	219	397	646	948	1515	2214	0.1486
60	2.35	4.30	11.5	20.7	31.2	51.3	93.7	156	234	424	691	1014	1623	2372	0.1703
70	2.50	4.56	12.3	22.0	33.1	54.4	100	166	248	451	734	1075	1722	2517	0.1919
80	2.63	4.81	12.9	23.2	34.9	57.4	106	175	262	475	774	1135	1814	2653	0.2134
90	2.76	5.05	13.6	24.3	36.6	60.2	111	183	275	499	812	1192	1893	2782	0.2347
100	2.88	5.27	14.2	25.4	38.3	62.8	116	191	287	520	848	1243	1990	2908	0.2560
120	3.10	5.69	15.3	27.4	41.3	67.9	125	207	310	562	915	1342	2148	3138	0.2985
150	3.38	6.26	16.8	30.2	45.5	74.7	138	228	341	619	1007	1477	2361	3450	0.3616
200	3.88	6.96	19.1	34.3	51.5	84.8	156	258	387	703	1144	1677	2685	3919	0.4664
250	4.33	7.86	21.1	37.9	57.1	93.7	173	285	428	776	1264	1855	2962	4337	0.5695
300	4.68	8.56	23.0	41.2	62.1	102	188	310	466	845	1376	2019	3226	4717	0.6748
350	5.03	9.22	24.7	44.5	66.8	110	202	334	501	908	1478	2168	3467	5060	0.7788

[a] From Marks' and Davis' Tables.

HEATING CONDUITS

Conduits for steam pipes buried underground should be water-proof, able to withstand earth loads and take care of the expansion and contraction of the piping without strain or stress on the couplings, also without affecting the installation or conduit. Expansion of the piping must be carefully controlled by means of anchors and expansion joints or bends so that the pipes can never come in contact with the conduit. Anchors can be anchor fittings or U-shaped steel straps which partially encircle the pipes and are firmly bolted to a short length of structural steel set in concrete.

In laying out conduits of this type the following points should be borne in mind:

1. The conduit should be laid out in successive straight runs between manholes or anchor pits.
2. An anchor should be placed wherever the line changes direction.

3. An expansion joint offset or bend should be placed between each two anchors.

4. Manholes should be provided at each expansion joint. Where slip joints are used manholes should be vented.

5. Branches should be taken off at or near an anchor.

6. If the distance between buildings is 150 ft. or less and the steam line contains high-pressure steam, it may be anchored in the basement of one building and allowed to expand into the basement of the second building. If the steam line contains low-pressure steam (up to 4 lb. pressure), this method may be used if buildings are 250 ft. or less apart.

7. If the distance between buildings is between 150 ft. and 300 ft. and the steam line contains high-pressure steam, the lines should be anchored midway between the buildings and allowed to expand into the basements of both buildings. If the steam line contains low-pressure steam this method may be used if buildings are between 250 ft. and 600 ft. apart. No manhole is required at the anchor, and a blind pit is all that is necessary.

8. For longer lines, manholes must be located according to judgment and depending upon the expansion value of the type of expansion joint or bend that is used. The minimum number of manholes will be required when an expansion bend or an anchor with double expansion joint is placed in each manhole and the pipes are anchored midway between manholes.

9. Stabilizers to maintain alignment of pipes should be placed on each side of each expansion joint or bend.

10. A proper hydrostatic test should be applied to the piping before the top of the conduit is applied and before application of insulation. The pressure used in this test should be greater than the pressure used in service, and should be not less than 100 lb. per square inch in any case.

11. In most types of conduit construction a drainage system is provided as a part of this construction. However, where the steam lines are laid at or near the level of sewers, or when tidal water is likely to give trouble, a separate drainage system should be installed and connected to a manhole at the lowest point and equipped with suitable pumping apparatus.

The styles and construction of conduits commonly used may be classified as follows:[1]

Filler Type: The pipes are supported on expansion rollers properly supported from the conduit or independent masonry base. The pipes are protected by a split-tile conduit, and the entire space between the pipes and the tile is filled with an insulating filler. Thus the pipes are nested and the insulation between them and the tile effectively prevents circulation of air. The conduit is placed on a bed of gravel or crushed rock from 4 to 6 in. thick, which is extended upward so as to come about 2 in. above the parting lines of the tile. A tile underdrain is placed beneath the conduit throughout the entire length and is connected to sewers or to some other point of free discharge.

Insulated Tile Type: The insulating material is molded to the inside of a split-tile conduit. The pipes are supported on expansion rollers usually. The space between the pipes and the insulating conduit lining may also be filled with an insulating filler. The conduit insulation, piping and earth load are supported by the base drain. A few inches of gravel or crushed rock are placed about the conduit and the base drain.

Sectional Insulation Type (Tile Conduit): Each pipe is insulated in the usual way with any desired type of sectional pipe insulation over which is placed a standard water-proof jacket with cemented joints. The pipes are enclosed in a split-tile conduit which is placed on a bed of crushed rock or gravel from 4 to 6 in. thick. This gravel bed is extended upward so as to come about 2 in. above the parting lines of the tile. Underdrains are sometimes omitted where this type is used; any water which seeps into the conduit being allowed to flow down the bottom of the conduit to the nearest manhole. Drains are laid from the floor of each manhole to some point of free discharge. The pipes are supported on roller frames and these, according to the type of conduit used, are either supported by the conduit itself or have their lower parts set in concrete, thus supporting the pipes independent of the conduit.

---

[1] For further data on pipe insulation, see Chapter 24.

Sectional Insulation Type (Tile or Concrete Trench): A type of construction frequently used in city streets, where service connections are required at frequent intervals, the pipes are insulated as described in the preceding paragraph, and are enclosed in a box or trench made either entirely of concrete, or with concrete bottom and specially constructed tile sides and tops. The pipes are supported on roller frames secured in the concrete.

Sectional Insulation Type (Bituminized Fibre Conduit): Each pipe is individually insulated and encased in a bituminized fibre conduit. The insulating material is 85 per cent carbonate of magnesia sectional pipe covering, applied in the usual manner as on overhead pipes, except that bands are omitted. After every fifth section of magnesia covering there is applied a short, hollow section of very hard asbestos material in the bottom portion of which rests a grooved-iron plate carrying ball-bearings upon which the pipe rides when expanding or contracting. This short expansion section is of the same outside diameter as the adjacent 85 per cent magnesia covering. Over the pipe covering and expansion device there are placed two layers of bituminized fibre conduit with all joints staggered and the surface of each conduit, finished with liquid cement. Conduits are placed on a bed of crushed rock or gravel, approximately 6 in. deep, and this is extended upward to about the center line of the conduit when trench is backfilled. Underdrains leading to points of free discharge are placed in the gravel or crushed rock beds.

PIPE TUNNELS

Where steam heating lines are installed in tunnels large enough to provide walking space, the pipes are supported by means of hangers or roller frames on brackets or frame racks at the side or sides of the tunnel. The pipes are insulated with sectional pipe insulation over which is placed a sewed on painted canvas jacket or a jacket of asphalt saturated asbestos water-proofing felt. The tunnel itself is usually built of concrete and water-proofed on the outside with membrane water-proofing. Tile drains are installed at each side or in the center below the level of the tunnel floor to prevent the building up of static water pressure on the outside of the construction.

On account of their relatively high first cost as compared with smaller conduits, walking tunnels are sometimes not installed where provision for the heating lines is the only consideration, but only where required to accommodate miscellaneous other services, such as for underground passage between buildings.

STEAM USED PER SQUARE FOOT OF RADIATION PER SEASON

The following factors are used in New York City for the different classes of buildings listed. The factors are based on maintaining for certain hours 70 deg. inside temperature with a minimum of 0 deg. outside and an average of 43 deg. for the heating season, eight months, October 1 to June 1. In this group are six types of buildings:

For manufacturing or commercial loft type, where steam is used to heat the premises during the day hours to maintain 65 to 68 deg. from 9 A.M. to 5 P.M. No Sunday or holiday use and no night use. *Factor:* 325 lb. per square foot of radiation per season.

For office buildings using steam during daylight hours only to maintain 70 deg. from 9 A.M. to 6 P.M. for approximately 240 days (heating season). No night use. *Factor:* 400 lb. per square foot of radiation per season.

For office buildings using steam during day hours and at night when required to 7, 8 and 9 P.M. (customary where there are stock brokers or banking offices), 204 days. *Factor:* 500 lb. per square foot of radiation per season.

For residences of the block type (not detached) where high-class heating service is required somewhat similar to apartment buildings. *Factor:* 550 lb. per square foot of radiation per season.

For apartment houses where high-class heating service is required. (Steam off at midnight). *Factor:* 650 lb. per square foot of radiation per season.

For hotels (commercial type) where very high-class service is required; 24-hour service. *Factor:* 800 lb. per square foot of radiation per season.

By assuming 1 sq. ft. of direct low-pressure steam radiation equivalent or required for each 100 cu. ft. of space heated, which seems a fair ratio in New York City, it is possible roughly to estimate the steam required per cubic foot of space, information which is often more easily obtained than the square feet of radiation.

Considerable additional data on the heating requirements of various types of buildings in a number of cities may be found in the section on Utilization in the Handbook of the *National District Heating Association*.

CHAPTER 26

SELECTION OF FANS AND MOTIVE POWER

Fan Characteristics; Selection of Fans; Motive Power; Drives; Noise.

IN order properly to select fans, it is necessary to know the requirements of the ventilating system and the characteristics of the various types of fans available.

The items of system requirements may include:

1. Cubic feet of air to be moved per minute.
2. The static resistance of the system.
3. The type of motive power available.
4. The nature of the load such as variable air quantities or pressures.

The items of fan characteristics to be considered may comprise:

1. Efficiency.
2. Noise.
3. First cost.
4. Space required.
5. Type of fan best suited to service required.

In order to facilitate the choice of apparatus, fan tables usually show the following factors for each size fan operating against a wide range of static pressures:

1. Volume of air in cubic feet per minute (68 deg. fahr.–50 per cent relative humidity —0.07488 lb. per cubic foot).
2. Outlet velocity.
3. Revolutions per minute.
4. Brake horsepower.
5. Tip or peripheral speed.
6. Static pressure.

The most efficient operating point of the fan is usually shown by either bold or italicized figures in the capacity tables.

Fans may be grouped into two general classes:

1. Disc and propeller fans, which produce motion of the air by the thrust effect of inclined blades.
2. Centrifugal fans or blowers, which produce air movement by the centrifugal force generated in a rotating column of air.

Centrifugal fans or blowers usually are housed, though certain types operate well without housing. These fans or blowers may be classified further, according to the type of wheel as follows:

1. Paddle wheel or steel plate type with radial blades.

2. Multiblade wheel with forward curved blades.
3. Multiblade wheel with radial blades.
4. Multiblade wheel with partially backward curved blades.
5. High speed fans with fully backward curved blades in the wheels.

CHARACTERISTIC CURVES

Characteristic curves are shown in Figs. 1 to 5, illustrating the performance of each type fan. Reference is made to the Standard Test Code for Disc, Propeller and Centrifugal Fans and Blowers, as adopted by the American Society of Heating and Ventilating Engineers and the *National Association of Fan Manufacturers*. Capacity tables usually list capacities between the dotted vertical range lines. All curves are for constant speed. The contour of performance curves will vary with different makes and designs, but all fans of a similar type have the same general characteristics.

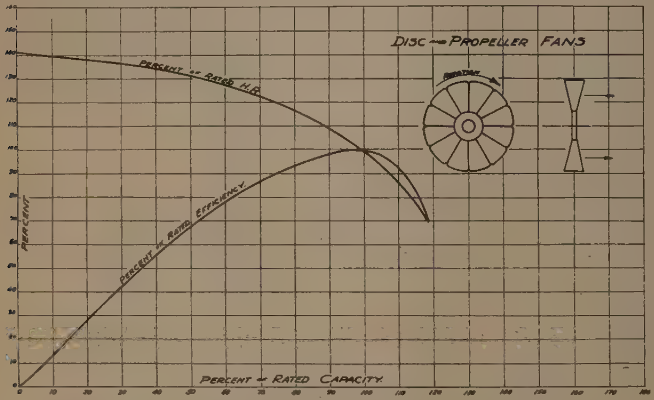


Fig. 1. Characteristics of Disc and Propeller Fans

DISC AND PROPELLER FANS

Application

Fans of this type are best adapted for free air delivery, or for operation against slight resistances. Disc fans when properly designed have a satisfactory efficiency at low resistance, being equal in this respect to good centrifugal fans or blowers. Under these conditions they excell in low cost and economy of operation. They are particularly desirable for use in the types of unit heaters which have low-resistance heating elements and for moving large volumes of air with little or no duct work. Although these fans can operate against considerable resistance, the power increases rapidly and the noise often becomes objectionable, so that they do not always compare favorably with centrifugal fans for such service.

Characteristics

The curves (Fig. 1) show the rapid reduction in capacity and increase in power as the resistance increases. The low efficiency when overcoming heavy resistance is due to the low speed of the blades near the hub as compared to the relatively high-peripheral or tip speed. The air driven by the blade area near the rim can pass back through the less-effective blade area at the hub more easily than it can overcome the duct resistance. The power required for fans of this type at increased speed, increases as the cube of the speed.

Drive

Disc and propeller fans lend themselves to direct connected motive power, as the speeds of sizes commonly used are high enough for standard electric motor speeds. In specifying direct connected electric motors it must be remembered that motors may be subject to dust, corrosive fumes, or high temperature gases. Enclosed and special cooled motors are available for this service. The fan wheel usually is suspended on the motor shaft. Horizontal fans (for vertical running), require motors of vertical type fitted with special bearings to take the thrust load.

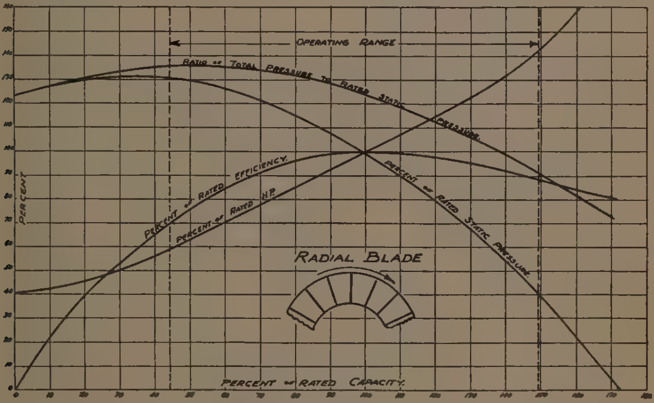


Fig. 2. Characteristics of Paddle Wheel Fans

Large size disc and propeller type fans usually are arranged for belt, multiple rope, or chain drive on account of the low shaft speed.

CENTRIFUGAL FANS AND BLOWERS

Application

With *centrifugal fans and blowers*, when the resistance is increased (at constant speed) the power and capacity decreases. The efficient operating range covers a considerable latitude of capacities and occurs when the static pressures produced are highest, making the centrifugal type fan preferred in any system having considerable resistance to overcome. The fan should be selected at or near the point of maximum efficiency.

Selecting a fan beyond this point results in higher capacity, high outlet velocity, lower efficiency and a tendency to create noise.

Characteristics

The *paddle wheel type fan* practically is obsolete for ventilation. Its use largely is confined to such applications as conveyors for material, or for gases containing foreign material, fumes and vapors. The open construction and the few large flat blades of these wheels render them resistant to corrosion and prevent material from collecting on the blades. Fig. 2 shows that over the entire useful range the static pressure and total pressure decreases as the capacity increases. The power curve is practically a straight diagonal line increasing from no-delivery to full open delivery. A larger size fan is required for a given capacity in comparison with multiblade fans.

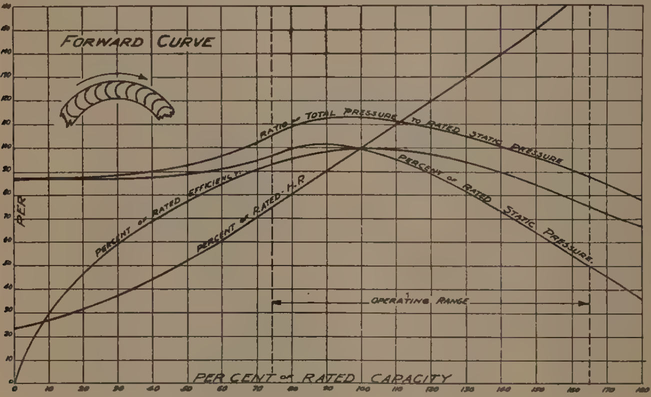


Fig. 3. Characteristics of Forward Curve Multiblade Fans

The *forward curved multiblade fan* is the type most commonly used in heating and ventilating work, as it has a low peripheral speed, a large capacity and is quiet in operation. The point of maximum efficiency for this fan occurs near the point of maximum static pressure. The static pressure drops consistently from the point of maximum efficiency to full open operation. Fig. 3 shows that this type of fan will have a high and low delivery for a given static pressure at constant speed. The power curve rises continually from low to peak capacity, but if reasonable care is exercised in figuring resistance there is no danger of overloading the motor.

The *partial backward curve multiblade type of fan* lends itself particularly to direct drive through a considerable range of sizes, as this fan must be driven approximately 75 per cent faster than the forward curve multiblade fan for the same results. Fig. 4 shows a continually dropping contour as the quantity of air delivered increases. The power curve gradually increases showing a tendency to flatten at maximum delivery, reducing the probability of motor overloads if the actual resistance is less than calculated. As with the paddle wheel fan the air delivery at a given speed is more constant with varying resistance than with the forward curved multiblade type. Multiblade fans with radial blades have performance characteristics resembling the partial backward curve multiblade fan, the outstanding difference being in the speed, as the radial type operates at approximately 80 per cent of the speed of the partial backward curve type for equal results.

FULL BACKWARD CURVE MULTIBLADE FANS

The outstanding characteristics of the *full backward curve multiblade type fan* are the steep pressure curves, the non-overloading power curve, and the high speed. This fan operates at a peripheral speed of approximately 250 per cent of the forward curve multiblade type for like results. The pressure curves begin to drop at very low capacity and continue to fall rapidly to full outlet opening. This makes the fan adaptable to parallel operation for such application as stoker installations. The steep pressure curves tend to produce constant capacity under changing pressures. Where wide fluctuations occur, the use of this type of fan is desirable to prevent overloading of motors. The maximum power requirement occurs at about the maximum efficiency. Consequently a motor selected to carry the load at this point will be of sufficient capacity to drive the fan over its full range of capacities at a given speed. The high speed of this type makes it adaptable for direct connected electric motor drives. The high speed necessitates heavier construction, and more operating attention and service is required than for the other type multiblade fans. The dimensional bulk for a given duty is 150 to 200 per cent that of a forward curve multiblade type fan.

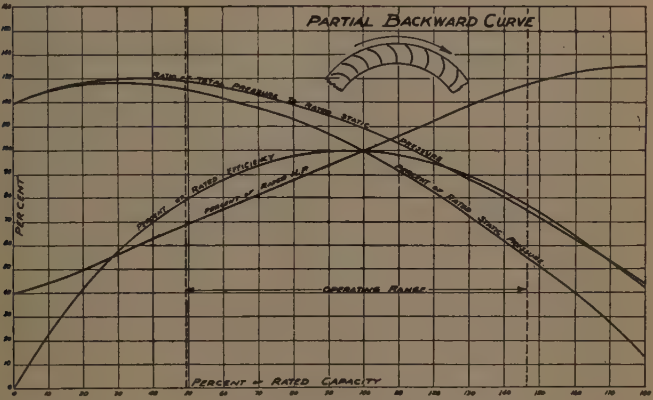


Fig. 4. Characteristics of Partial Backward Curve Multiblade Fans

SELECTION OF FANS FOR VENTILATION

Two important factors in selecting fans for ventilating systems are: efficiency (which affects the cost of operation) and noise. First cost and space available are secondary. The fans should be selected to operate at maximum efficiency without noise. Noise in a ventilating system is irritating and a cause for complaint. Fans must be selected of proper size in order to reduce it to a minimum. Noise may be caused by other factors than the fan, namely, high velocity in the duct work, unsatisfactory location of the fan room, improper construction of floors and walls and poor installation. Where noise is chargeable directly to the fan, it is caused either by excessive peripheral speeds, or the fan is of insufficient size. A noisy fan usually is one which is operated at a point considerably beyond maximum efficiency.

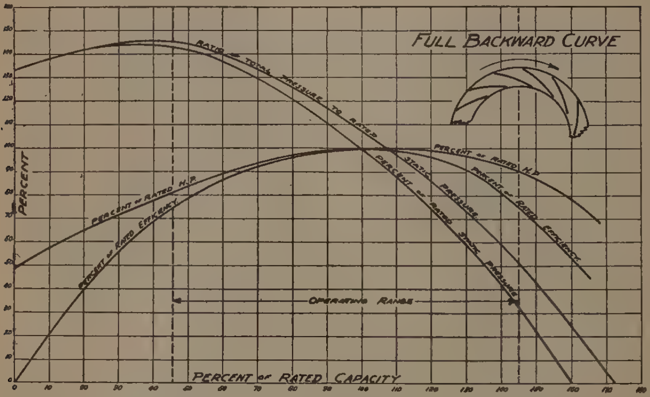


FIG. 5. CHARACTERISTICS OF FULLY BACKWARD CURVED MULTIBLADE FANS

For a given static pressure there is a corresponding outlet velocity and peripheral speed wherein maximum efficiency is obtained. If a fan be selected to operate at this point, the cost of operation and the noise can be held within control.

To aid in selecting fans as near as possible to the point of maximum efficiency, there are listed for each static pressure, corresponding outlet velocities and tip speeds which will give satisfactory results. The proper tip speed for a given static pressure varies with design of wheel and number of blades or vanes in wheel.

Lower outlet velocities than listed in Table 1 may be used, but care must be exercised to avoid selecting a fan for operation below its useful range.

In exhaust ventilating systems where the air column moves toward the fan, noise due to the higher tip speeds and outlet velocities, will not be so readily transmitted back through the air column to the building.

Therefore, higher outlet velocities, up to as much as 2,000 ft. per minute may be used, but this will be at the expense of increased power.

Amply large fans should always be used for both exhaust and supply systems, as there may be and usually is leakage despite the most careful workmanship, necessitating the delivery of more air at the fans than is exhausted from or supplied through the openings in the various rooms.

Long runs of distributing ducts, heaters, air washers, etc., usually are parts of any ventilating system where high static pressures are needed. Under such conditions it is practicable to select fans with higher outlet velocities and peripheral speeds since the duct system itself will tend to muffle objectionable air sounds.

Fans with low outlet velocities should be used regardless of the static pressure, if connected with short ducts to register faces, on account of noise.

TABLE 1. GOOD OPERATING VELOCITIES AND TIP SPEEDS FOR FORWARD CURVED MULTIBLADE VENTILATING FANS

STATIC PRESSURE IN INCHES OF WATER	OUTLET VELOCITY FEET PER MINUTE	TIP SPEED FEET PER MINUTE
¼	1000–1100	1520–1700
⅜	1000–1100	1760–1900
½	1000–1200	1970–2150
⅝	1100–1300	2225–2450
¾	1200–1400	2480–2700
⅞	1300–1600	2660–2910
1	1500–1800	2820–3120
1¼	1600–1900	3162–3450
1½	1800–2100	3480–3810
1¾	1900–2200	3760–4205
2	2000–2400	4000–4500
2¼	2200–2600	4250–4740
2½	2300–2600	4475–4970
3	2500–2800	4900–5365

FANS FOR DRYING

Both disc and centrifugal types of fans are used for drying work. Disc fans are well adapted to the removal of moisture-laden air when operating against low resistance and when handling air at low temperatures.

Motors on these fans usually are of the fully-enclosed moisture-proof types so that saturated air or air containing foreign material will not injure the motors.

Unit heaters employing disc or propeller type fans are widely used in the drying field. In drying, disc or propeller fans may be used where not too much duct work is required and where air is to be delivered against pressure, since the noise developed from the high peripheral speed of these fans is not ordinarily objectionable in process work of this nature.

Centrifugal fans or blowers of the multiblade type generally are selected to supply air for drying, as they are capable of delivering large volumes against all pressures with a minimum amount of power.

Belt driven fans usually are to be preferred to direct-connected fans as they make a more flexible and economical unit. Wherever drying is done throughout the year and where air requirements change as the drying conditions change, the drying can be speeded up or reduced through control of the fan capacity. This may be done by changing the fan speed or by varying the outlet area with dampers.

Due to the low speeds of forward curved multiblade or paddle wheel type fans, these can be direct-connected to reciprocating steam engines and the exhaust steam may be used in the heating apparatus. In selecting engine driven fans for drying processes, where a large quantity of exhaust steam is used in the heaters, a smaller fan and greater power consumption may be used, because power economy is not essential under this condition.

Where static pressure in a dryer varies, and where battery operation is required, the full backward curved fan is recommended. This type is well adapted for direct-connected motors of the higher speeds.

FANS FOR DUST COLLECTING AND CONVEYING

The application of fans or exhausters for handling refuse, dust, fumes, etc., generated by machine equipment is covered in Chapter 31. Information is given regarding the methods for determining air quantities, velocity required for carrying various materials and method of determining maintained resistance or total static pressure at which the fan is to operate.

The selection of a proper size fan or exhauster is at times governed by the future requirements of the plant. In many instances, additional future capacity is anticipated and should be provided for.

Having determined the necessary volume of air and the maintained resistance or static pressure required, the proper size fan may be selected from the fan manufacturers' performance charts or capacity tables. If the fan is to be pulley-driven, its selection is a simple matter. The fan chosen would be the size that will provide the required ultimate quantities with the minimum power consumption.

MOTIVE POWER

Motive power for fans should be determined in accordance with the Standard Code of the American Society of Heating and Ventilating Engineers, Transactions, Vol. 29, 1923; p. 442.

It is no easy matter to predetermine the exact resistance to be encountered by a fan, or having determined this resistance, to insure that no changes in construction or operation shall ensue which may increase air resistance, thus requiring more fan speed and power to deliver the required volume, or which may reduce air resistance, thus causing delivery of more air and a consequent increase of power even at constant speed.

It is recommended, therefore, for centrifugal type fans that the rated power to be supplied shall exceed the rated fan power by a liberal margin, depending on the type of blade, of from 10 per cent minimum, to about 25 per cent maximum.

Justification for liberal power provision exists also in the possibility of varying demand due to changes in ventilation requirements, intensity of occupation, weather conditions, etc.

CONTROL

Some method of volume control of fans usually is desirable. This may be done by varying the peripheral velocity, or by interposing resistance, as by throttling-dampers. Both methods, since they reduce the volume of air, reduce the power required. In many installations adjustments of volume are desirable during varying hours of the day. In others an increased supply of air in summer over that needed for winter is demanded. Experience is required in deciding whether speed-control or damper-control shall be used for specific cases. Where noise is a factor, it may be exceedingly desirable to reduce the speed at times, while on the other hand, any fan which has its normal speed reduced as much as 50 per cent without *change in resistance* will move only 50 per cent of the air.

ELECTRIC MOTORS

Electric power is almost the universal solution for fan operation, as electric motor speeds are flexible for adapting to direct-connected fans. Electric motors are readily suited to various types of drives, such as belts, chains or gears.

Each type of electric motor and kind of electric current has its advantages and disadvantages as applied to a fan application.

Direct-connected electric motors usually are very efficient for fan driving because there is no slippage due to belts, and no wear or noise due to chains or gears. There is less maintenance and upkeep to a direct-connected unit, and with an overhung fan wheel on the motor shaft, the usual fan bearings are eliminated.

The disadvantage of a slow-speed direct-connected motor is that it may be unduly large and heavy as well as costly, but this may be offset by the compactness of the unit as a whole due to limited space for fan equipment.

Should anything go wrong with a slow-speed direct-connected motor there may be a considerable delay in securing replacements, as these motors are not usually carried in stock, as is the case with moderately high-speed motors.

If a change of speed is found necessary with a direct-connected motor, it will mean a change of motor, which may necessitate a change in the motor foundation usually built with the fan in such cases. On the other hand, non-direct-connected motors have transmissions subject to wear and slippage, and chains or gears may be noisy with this latter type. However, should a change in speed be necessary where the motor is not direct-connected, changes in speed ratio can easily be accomplished by changing pulleys, sprockets or gears on either the fan or the motor. In the case of a motor breakdown a standard stock motor may easily be substituted.

A type of drive using wedge-shaped rope-like belts, often in multiple, has become very popular recently as it enables the use of high speed motors with slow speed fans. These motors are less expensive and more efficient, and further allow very short belt centers, saving floor space, thus making the fan unit and the motor much more compact than the usual belt drive. The compactness secured by this equipment compares favorably with a direct connected layout. This type of drive is also very quiet in operation, being similar to a conventional belt drive in this respect.

Alternating current motor designs are such that improved operating characteristics are obtained with the higher motor speeds. Efficiencies and power factors are improved over those in effect with slower speed motors, thus showing a considerable saving in power consumption, where some effective speed reducing transmission device to the fan, is installed.

Quietness of operation is more readily obtained with moderately high speed induction motors than with low speed motors, as any slight magnetic unbalance is not as easily heard. Magnetic unbalancing at times causes noises whose repetition and wave length is such as to cause vibrations and harmonics. Amplifications of the noises in other parts of a building remote from the motor equipment are sometimes found, due to such noises being carried by the steel work, ducts, or piping in the building. There is considerable evidence that these sounds are more easily controlled with higher motor speeds than with lower motor speeds.

Motors which are practically quiet in operation and free from magnetic disturbing noises can be obtained and should always be specified for quietness of operation when used for fan installations in buildings where quietness is a factor.

Even though quiet operating motors may be secured, the fan and motor foundations should be insulated from the building structure and the duct system should have a suitable connection made by canvas or other nonmetallic substance so as to prevent direct metallic contact between the fan and the building.

In the construction of fan and motor foundations where the machinery is mounted on the floor or upon a concrete platform, it is a usual practice to install a layer of cork on top of which is laid or floated the base which carries the apparatus. It is essential that the bolts or lag screws which fasten the machines to this foundation shall not extend through to the floor. It is wise to fasten curbs to the floor, these presenting insulated surfaces to the machinery foundation and so preventing it from traveling.

Kinds of Electric Motors

Direct current electric motors are extremely satisfactory for fan drives on account of quietness in operation and flexibility in the selection of speeds. Regulation in speed below as well as above the normal operating range may readily be secured by means of either manual or automatic controllers.

Single phase constant speed motors are satisfactory and available. Single phase adjustable speed motors (repulsion type) in small sizes are available, but are satisfactory only when the load is constant. The repulsion single phase motor has an inherent characteristic of being subject to change of speed with a change in load. It should not, therefore, be used in driving centrifugal housed fans where there is any restriction in the fan intake or discharge lines, such as a damper. Shutting off the air intake or air outlet from a centrifugal housed fan relieves the motor of most of the load and, with a repulsion single phase motor, the speed attained because of this light load would be objectionable from a noise standpoint and might do some damage to the fan wheel itself. With a disc or propeller type of fan, the repulsion motor is quite satisfactory because if the air outlet is closed, the load on the motor is still maintained.

Single phase motors require special starting devices which are often noisy and troublesome as compared with the more simple devices available for use with direct current or polyphase motors.

A single phase motor known as the condensor type, has been developed recently which is very quiet in operation, requiring no starting devices in the motor. The motor is similar to a polyphase motor, being without brushes or starting devices. A condenser in series with one of its windings is used to secure the starting torque. This type of motor has a low starting torque well adapted to direct-connected fans, and can be secured in high speeds as well as in low speeds.

Polyphase motors generally are satisfactory for driving fans and are made for constant speed, known as squirrel cage type and for variable speed, known as slip ring type. Both types are available for quiet operation, making them suitable for direct connection for moderately slow speeds. They are not as adaptable to exceedingly slow speeds as are direct current motors on account of low power factor and low efficiency at these speeds.

For slow speed fans, a belt drive of some efficient type is desirable so as to permit use of the higer speed polyphase motor, the design of which has a high efficiency and a more satisfactory power factor.

A new polyphase motor known as the high reactance, self-starting squirrel cage type has become quite popular for fan applications.

It does not require any cumbersome manually-operated starting compensator in sizes up to 30 hp. It may be thrown directly across the line in starting. These motors are designed to give about 100 per cent starting torque, which makes them very suitable for fans; and the instantaneous current demand does not exceed the limits set by the *National Electric Light Association.*

By the use of a magnetic contactor, this type of motor may be installed for remote control and the cost with the controller is less than that of the standard squirrel cage motor with a manually-operated compensator.

There are available also *variable speed polyphase slip ring* type induction motors, suitable for reduction in speed from the normal operating speed to 50 per cent below normal.

It is seldom necessary to reduce the speed of a ventilating fan more than 50 per cent from the maximum fan speed.

Control for Electric Motors

Very small direct current motors may be started by throwing them directly on the line through a suitable starting switch. The larger sizes require some type of starting rheostat. When speed adjustment is desired, the controller for adjusting the speeds of the motor usually functions also as a starting device.

Alternating current motors of 5 hp. and under, usually may be thrown directly on the line. It is good practice to use a starting switch equipped with a thermal overload or inverse time limit overload device. This type of switch provides protection to the motor beyond the power of fuses to supply. Fuses when used necessarily must be large enough to take care of the inrush current which makes them inadequate for protecting the motor under operating conditions. The thermal overload device allows for this inrush and does not function until an overload has become persistent, the time element depending upon the percentage of overload over the rating of the element.

This type of switch is available for manual operation and also is furnished in the magnetic type for remote operation by push-button, or for operation by other types of pilots such as pressure switches and thermostats.

On the standard squirrel cage motors above 5 hp. a starting compensator usually is employed to keep the inrush current to within the limits specified by the local power companies. Compensators may be obtained in transformer type and primary resistor type, and usually are furnished for manual operation. They can be secured for remote control also, but are necessarily expensive. However, the new type of high reactance, self-starting motors, may usually be thrown across the line up to 30 hp. in size, and still have their inrush current within the limits of the rules of *National Electric Light Association*. With this type of motor a magnetic contactor usually is used. This device may be operated from a remote point by push-button, if desired. These magnetic contactors are furnished usually with thermal overload and no-voltage protection.

For remote operation of motors through magnetic starters, the operating buttons may be located in the engineer's or manager's office, and tell-tale indicating lamps may be wired up with the circuit to indicate whether or not the unit is in operation.

This type of control is very desirable in large buildings where the engineer is to have complete charge of the ventilating system.

Remote or automatic control of the units may be effected also by pneumatic or hydraulic apparatus, or by thermostats or by pressure devices which are provided with electric contacts for starting or stopping the units upon reaching certain conditions.

Variable speed slip ring motors and direct current motors may also be arranged for remote speed control by means of pre-set automatic regulators, where the operating speed of the motor is set by a dial-switch or regulator (which may be near the fan or at a remote point) and the motor is then automatically controlled at this speed merely by operating the remote control push-button for starting or stopping the equipment.

Arrangements may be made for remote control of fan motors, or for automatic control by influence of temperature. Remote control may be by pneumatic or by hydraulic manipulation as well as by electrical means.

In many large ventilating systems which have heating plants in connection, steam engines are used to operate fans. A medium speed steam engine, exhausting at low pressure into the radiators which heat the building or which warm the air, is a very economical source of power, is quiet in operation, and has a wide range of speed variation. The steam economy of such an engine usually is of little importance, since the engine serves as an auxiliary to the pressure-reducing valve interposed in such cases between the boiler and the radiators.

Internal combustion engines and line shafting are often used for fan driving, requiring clutches or shift-belts with loose pulleys in order to secure proper starting and control.

GENERAL SUGGESTIONS

Single inlet, single width fans should be selected wherever possible. If double width, double inlet fans are selected, care must be taken that both inlets have the same free area. If one inlet is obstructed more than the other, the fan will not operate properly, as one half of the wheel will deliver more air than the other half.

Where duct connections are made on double width fans, static pressure on both inlets must be carefully balanced; otherwise, the fans may be over or under capacity. Inlet connections on double width fans necessitate the driving arrangement on the outside with extended shafts and outboard pedestals. It is not considered good practice to drive the belt through duct connections.

In selecting the discharge and rotation of the fan, the design of the duct should be continuous with the fan scroll.

DESIGNATION OF FANS[1]

This method of designation will apply to all centrifugal fans, single or double width, and single or double inlet. Do not use the word "hand," but specify "clockwise" or "counter-clockwise."

Facing the driving side of the fan, blower or blast wheel, if the proper direction of rotation is clockwise, the fan, blower or blast wheel will be designated as *clockwise*. If the proper direction of rotation is counter-clockwise, the designation will be *counter-clockwise*. (The driving side of a single inlet fan is considered to be the side opposite the inlet regardless of the actual location of the drive).

The discharge of a fan will be determined by the direction of the line of air discharge and its relation to the fan shaft, as follows:

Bottom Horizontal: If the line of air discharge is horizontal and below the shaft.

Top Horizontal: If the line of air discharge is horizontal and above the shaft.

Up Blast: If the line of air discharge is vertically up.

Down Blast: If the line of air discharge is vertically down.

All intermediate discharges will be indicated as angular discharge as follows:

Either top or bottom angular up discharge or top or bottom angular down discharge, the smallest angle made by the line of air discharge with the horizontal being specified.

ARRANGEMENT OF DRIVE

For the convenience of fan users, and to prevent misunderstandings which cause delays and losses, the following suggestions are made for such arrangements of drive which are most often used. Reference to the various arrangements will be understood as referring to Fig. 6.

Arr. 1. For Belt Drive.

Single fan. Wheel overhung. Includes housing, wheel, shaft, two bearings, pedestal and pulley.

Arr. 2. For Belt Drive.

Single fan. Pulley overhung. Includes housing, wheel, shaft, two bearings and pulley.

---

[1] Recommendations adopted by the *National Association of Fan Manufacturers.*

Arr. 3. For Direct Connection.

Single fan. Includes housing, wheel and base. Wheel is overhung on engine or motor shaft.

Arr. 4. For Direct Connection.

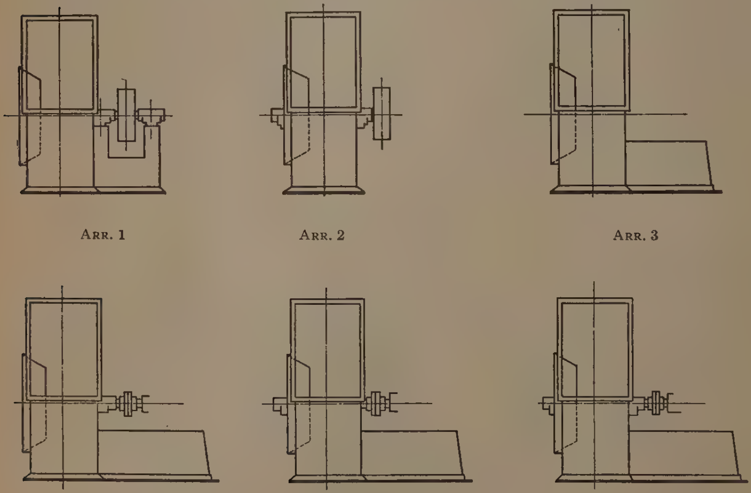
Single fan. Includes housing, wheel, shaft, one bearing on drive side of fan, flanged coupling and base.

Arr. 5. For Direct Connection.

Single fan. Includes housing, wheel, shaft, two bearings, flanged coupling and base.

Arr. 6. For Direct Connection.

Single fan. Includes housing, wheel, shaft, two bearings, flexible coupling and base.



ARR. 1 ARR. 2 ARR. 3

ARR. 4 ARR. 5 ARR. 6

FIG. 6. ARRANGEMENT OF FAN DRIVE

Arrangement 1. Fan is of the overhung wheel type with the two bearings mounted on one side and the driving pulley in between. Arrangement 1 is preferred where the fan exhausts from shafts making the inlet bearing inaccessible. It is also used for high temperatures and other conditions where it would be impossible to locate the bearing in the fan inlet.

Arrangement 2 is furnished with a bearing on each side with the wheel supported in the center. This fan is arranged for driving with belt, which permits the use of high-speed efficient electric motors which can be purchased at a low initial cost. Arrangement 3 can be purchased at a lower initial cost than any other type shown.

Arrangement 3. Fan is used for practically all direct-connected work. The fan motor is mounted directly on the motor shaft, the motor being mounted on a pedestal built integral with the fan housing, both motor bearings being easily accessible.

Arrangements 4, 5 and 6 are used in larger fans where the fan wheel is of such weight as to not permit it being suspended on an extended motor shaft.

CHAPTER 27

AIR DUCTS

Design and Installation of Air Ducts; Friction Losses; Insulation of Ducts.

THE proper functioning of any system requiring the transmission of air or dust is dependent to a large extent on the correct design of the ducts.

FUNDAMENTALS OF DUCT DESIGN

The sizes of ducts and flues for gravity or mechanical circulation of air are based on the losses due to friction, and these losses must be kept within the available pressure difference. This pressure difference in mechanical ventilation is that derived from the fan, while in gravity ventilation the aspirating effect due to the temperature and height of the column of heated air causes the pressure difference.

The general rules to be followed in the design of a duct system are:

1. The air should be conveyed as directly as possible at reasonable velocities to obtain the result desired with greatest economy of power, material, and space.
2. Sharp elbows and bends are to be avoided.
3. All ducts or flues shall have sides as nearly equal in size as possible. (In no case shall the ratio between long and short sides be greater than 10 to 1.)

The ducts for a school, theater or other public building, where freedom from noise and elimination of drafts is essential and where branch ducts serve individual rooms, present more difficult problems in design than are involved in proportioning ducts intended for heating a factory, where a main duct of decreasing dimensions extends lengthwise of the building and gives a uniform distribution of air. For public buildings air velocities must be kept low, the range being from 900 to 1,200 ft. per minute while in industrial buildings velocities may range from 1,500 to 2,000 ft. per minute or even more.

The higher velocities reduce the cost of the ducts but, of course, increase the cost of power for driving the fans.

The standard velocities of air for public buildings are as follows:

1. Through the outside air intakes 1,000 ft. per minute.
2. Through connections to and from heater 1,000 to 1,200 ft. per minute.
3. Through the main discharge duct from 900 to 1,200 ft. per minute.
4. In branch ducts 600 to 1,000 and vertical flues 400 to 800 ft. per minute.
5. In registers or grilles 200 to 400 ft. per minute depending upon the size and location.
6. If diffusers of proper design are used, 25 per cent higher air velocities may be permitted.

It is customary in proportioning ducts for heating and ventilating work to follow either of two methods:

TABLE 1. PRESSURES AND CORRESPONDING VELOCITIES OF DRY AIR AT 70 DEG. AND 29.92 IN. BAROMETER

INCHES OF WATER	OUNCES PER SQ. IN.	VELOCITY FT. PER MIN.	INCHES OF WATER	OUNCES PER SQ. IN.	VELOCITY FT. PER MIN.
0.05	0.0289	896	4.77	2.750	8745
0.10	0.577	1266	5.00	2.884	8943
0.20	0.1154	1791	5.20	3.000	9134
0.25	0.1443	2003	5.50	3.172	9392
0.30	0.1730	2193	6.00	3.460	9810
0.40	0.2308	2533	6.07	3.500	9864
0.43	0.2500	2637	6.50	3.749	10210
0.50	0.2884	2832	6.94	4.000	10545
0.60	0.3460	3102	7.00	4.037	10595
0.70	0.4037	3351	7.50	4.326	10968
0.75	0.4326	3468	7.80	4.500	11187
0.80	0.4614	3582	8.00	4.614	11328
0.87	0.5000	3729	8.67	5.000	11792
0.90	0.5190	3800	9.00	5.190	12015
1.00	0.5768	4005	9.54	5.500	12367
1.25	0.7209	4478	10.00	5.768	12665
1.30	0.7500	4566	10.40	6.000	12915
1.50	0.8650	4905	11.00	6.344	13282
1.73	1.0000	5273	11.27	6.500	13445
1.75	1.0092	5298	12.00	6.921	13875
2.00	1.1535	5664	12.14	7.000	13950
2.17	1.2500	5895	13.00	7.497	14440
2.25	1.2975	6007	13.87	8.000	14913
2.50	1.4418	6332	14.00	8.074	14985
2.60	1.5000	6457	15.00	8.650	15510
2.75	1.5860	6641	15.61	9.000	15820
3.00	1.7300	6937	16.00	9.227	16020
3.03	1.7500	6976	17.00	9.805	16513
3.25	1.8740	7220	17.34	10.000	16675
3.47	2.0000	7457	18.00	10.380	16990
3.50	2.0185	7492	19.00	10.960	17456
3.75	2.1630	7756	19.07	11.000	17488
3.90	2.2500	7910	20.00	11.535	17910
4.00	2.3070	8010	20.81	12.000	18265
4.25	2.4510	8256	22.54	13.000	19012
4.34	2.5000	8337	24.28	14.000	19730
4.50	2.5950	8496	26.01	15.000	20420
4.75	2.7395	8729	27.74	16.000	21090

TABLE 2. VELOCITIES OF DRY AIR AT VARIOUS PRESSURES AND TEMPERATURES AND 29.92 IN. BAROMETER

PRESSURE		50°	60°	70°	100°	150°	300°	500°	550°
Inches	Ounces								
0.25	0.1443	1965	1986	2003	2059	2149	2399	2696	2895
0.5	0.2884	2778	2808	2832	2911	3038	3391	3812	4095
0.75	0.4326	3402	3439	3468	3565	3720	4153	4668	5020
1.00	0.5768	3929	3971	4005	4117	4296	4796	5390	5795
1.25	0.7209	4393	4440	4478	4602	4804	5362	6027	6470
1.50	0.8650	4812	4864	4905	5042	5262	5874	6602	7100
1.75	1.0092	5197	5254	5298	5446	5683	6344	7131	7655
2.00	1.1535	5556	5616	5664	5822	6076	6783	7624	8195
2.25	1.2975	5892	5956	6007	6174	6443	7193	8085	8690

1. Arbitrarily select sizes from assumed velocities, depending upon velocity of air at fan outlet.
2. Determine the velocity which will give an assumed resistance within fan capacity at noiseless operating speed.

By decreasing the velocity in main duct as air is delivered through branch outlets: (1) more uniform air delivery through outlets is accomplished, (2) friction in smaller pipes is reduced, (3) portion of velocity head is converted into static pressure.

FRICTION LOSSES

The two greatest losses in duct systems are the dynamic losses and the friction losses. The former are chiefly caused by changes in direction or in velocity of air flow and are expressed as pressure in inches of water gage—see Tables 1 and 2.

The loss of head caused by friction, which is numerically equal to the pressure required to maintain a given velocity, may be most easily expressed by the modification of the Fanning formula, when, dealing with round pipe and standard air (70 deg. fahr. — 29.92 in. Barometer).

$$h = z \frac{L}{D} h_V = \frac{L}{ED} \left(\frac{V}{4005}\right)^2 \quad \text{.......... (1)}$$

When dealing with rectangular ducts and standard air,

$$h = z L \left(\frac{a+b}{2ab}\right) h_V = \frac{L}{E} \left(\frac{a+b}{2ab}\right) \left(\frac{V}{4005}\right)^2 \quad \text{.......... (2)}$$

where

$$\begin{aligned} h &= \text{loss of head in inches of water.} \\ V &= \text{velocity of air in feet per minute.} \\ &\left.\begin{aligned} L &= \text{length of pipe.} \\ D &= \text{diameter of pipe.} \\ a &= \text{one side of rectangular duct.} \\ b &= \text{other side of rectangular duct.} \end{aligned}\right\} \text{All in feet or inches.} \\ z &= \text{coefficient of friction which varies from about 0.01 to 0.03.} \\ E &= \text{length of pipe in diameters for one head loss.} \end{aligned}$$

It will simplify calculations to consider that the values of z and E vary only with the nature of the pipe surface. Thus, E may be taken as about 60 for smooth pipe, such as used in planing mill exhaust systems; $E = 50$ for ordinary galvanized iron heating and ventilating ducts; and $E = 45$ for smooth and 40 for rough conduits of tile, brick or concrete.

The values of z and E not only vary with the roughness of the inside surface of the pipe, but also with the diameter and velocity. The coefficient of friction z decreases with both increase of diameter and velocity. It also varies directly with the air density and approximately inversely as the absolute temperature.

Fig. 1 will be found very convenient for determining the friction for a given air capacity in various size ducts at corresponding velocities. The coefficient of friction has been corrected for the various diameters and capacities, based on the rule that the coefficient of friction varies inversely as the 2/7 power of the diameter, and inversely as the 1/7 power of the capacity. This chart is based on a loss of one velocity head

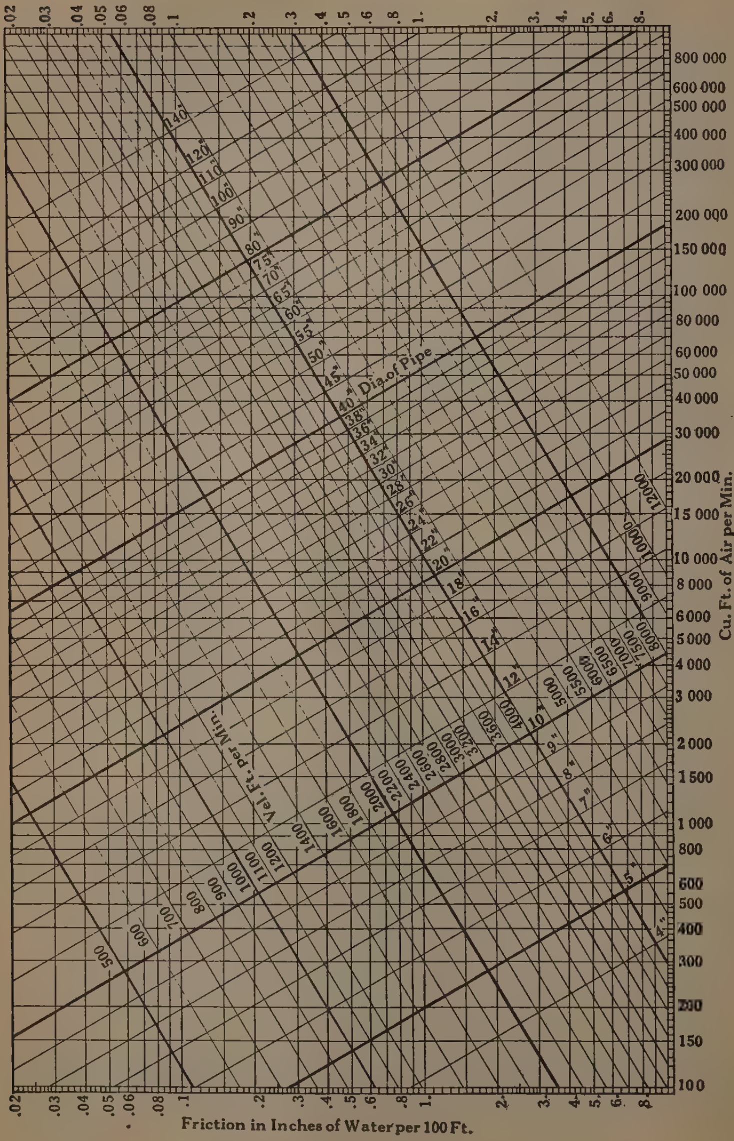


FIG. 1. FRICTION OF AIR IN PIPES

(at a velocity of 2,000 ft. per minute) in a length equal to 50 diameters of 24-in. galvanized swedged pipe.

As an example of the use of the chart: Assume that it is desired to pass 10,000 cu. ft. of air per minute through 75 ft. of 24-in. diameter pipe. Find 10,000 cu. ft. of air per minute on the right scale and move horizontally left to the diagonal line marked 24 in. The other intersecting diagonal shows that the velocity in the pipe is 3,200 ft. per minute. Directly below the intersection it is found that the friction per 100 ft. is 0.59 in., then for 75 ft. it will be $0.75 \times 0.59 = 0.44$ in. In a like manner any two variables may be determined by the intersection of the lines representing the other two variables.

Other losses of pressure are at the entrance to the duct, through heater, air washer, etc. In ordinary practice it is usual to keep the sum of the piping losses ⅓ to ½ and the loss through heater at less than one half of the static pressure. The remainder is then available for producing velocity.

In the design of an ideal duct system, all factors should be taken into consideration and the air velocities proportioned so that the resistance will be practically equal in all ducts regardless of length.

Friction in Elbows

Experience has shown that with an elbow of radius $R = 1\frac{1}{2} D$, fairly good results may be obtained. The loss with such an elbow will be about 17 per cent of a velocity head for round ducts and about 8 per cent of a velocity head for square ducts. It has been found of little or no advantage in making an elbow of a radius greater than two diameters. If, however, a smaller radius than $1\frac{1}{2} D$ be used, the losses increase rapidly. For instance, the loss for an elbow of $R = 1 D$ will be as high as 17.5 per cent of a velocity head for square ducts and 25.5 per cent for round ducts.

For ordinary calculations one easy long radius elbow ($R = 1\frac{1}{2} D$) in a circular pipe may be considered as equal in friction loss to 10 diameters of straight pipe.

Proportioning the Size for Friction

By means of Figs. 2 and 3 the diameter of branch pipes necessary to carry a given percentage of the total air in the main pipe with the same friction per foot of the length may be determined.

For example: Suppose a 60-in. main pipe is to be used, and it is desired to know the size of branch pipe required to carry 50 per cent of the total air in the main. Find 50 per cent at the left of the chart, move right to the 60-in. diagonal line and note directly above at the top of the chart, that the branch pipe will be a 45.5-in. diameter.

Where rectangular ducts are used it is frequently desirable to know the equivalent diameter of round pipe to carry the same capacity and have the same friction per foot of length. Table 3 gives directly the circular equivalent of rectangular ducts for equal friction and capacity.

To obtain the size of rectangular pipes for different capacities but of the same friction per foot of length, first obtain the equivalent round pipe for equal friction. Thus, if a branch of sufficient size to carry 30 per cent of a 12 x 36-in. pipe is desired, it is found from Table 3 that

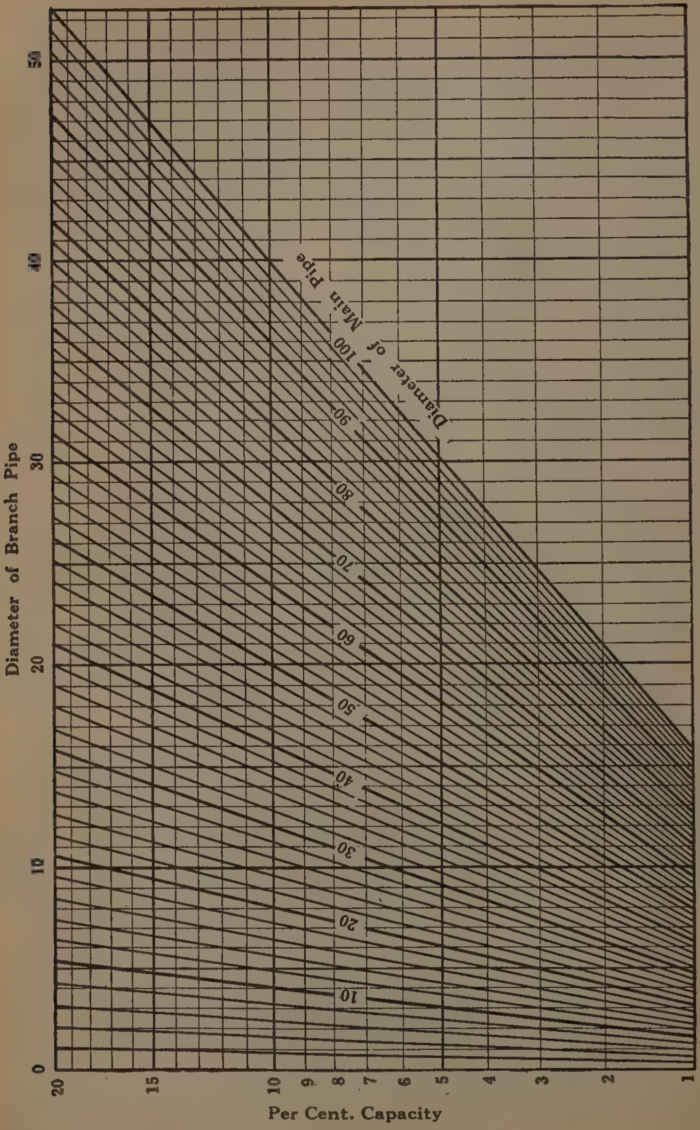


Fig. 2. Main and Branch Pipes for Equal Friction per Foot of Length

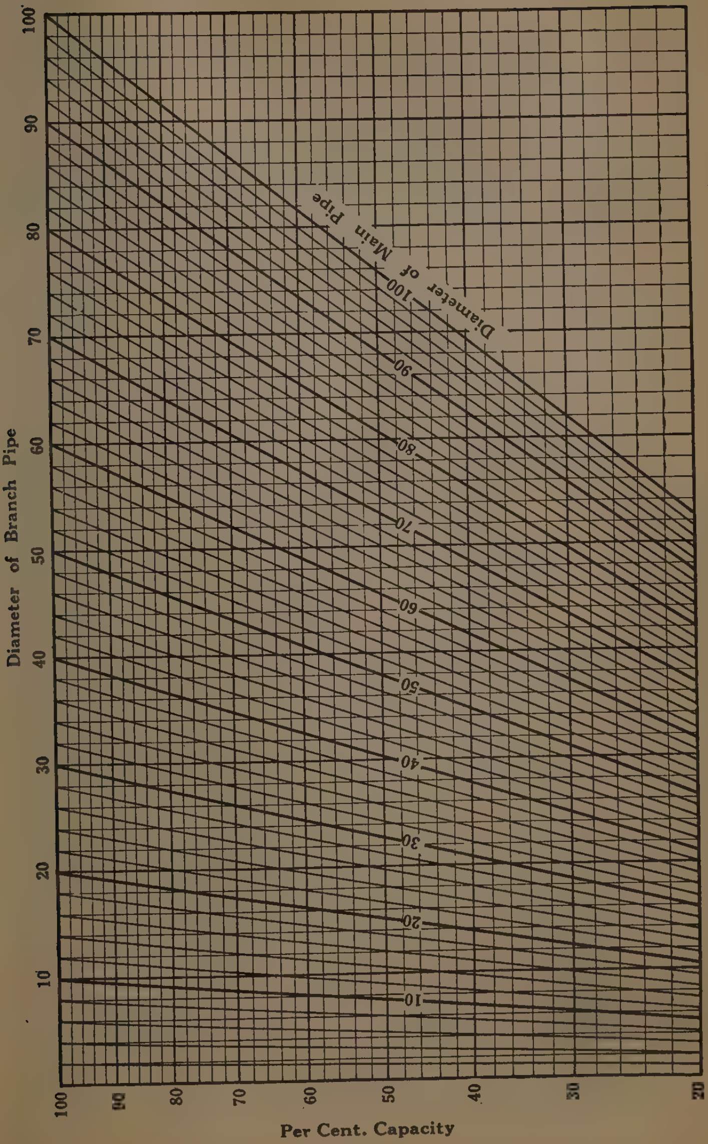


FIG. 3. MAIN AND BRANCH PIPES FOR EQUAL FRICTION PER FOOT OF LENGTH

the main is equivalent to a 22.2-in. diameter round pipe. From Fig. 3, 30 per cent of this is a pipe 13.5 in. in diameter, and referring again to Table 3, the rectangular equivalent branch is a 12 x 13-in., 10 x 15-in. or any other desirable combination.

Exhaust Systems

In the design of piping for an exhaust system where no dampers are provided, it is considered good practice to make the area of the main pipe approximately 20 per cent greater than the sum of the areas of the branch pipes at that point. This method gives greater uniformity of distribution than where the increase in area is not made.

INSTALLATION OF AIR DUCTS

The following suggestions will be found helpful in the installation of air ducts:

1. For heating and ventilating work, ducts 6 x 6 in. represent a minimum size. In any place where other considerations do not outweigh, round pipe for small flues is recommended.
2. Abrupt turns or sharp bends should never be made. Elbows should have a throat radius equal to the depth of the duct.
3. Transformations and offsets should not be made abruptly. Angles greater than 45 deg. should be avoided. In any case, care should be taken not to restrict the true cross-sectional area.
4. Tees or branches from main ducts should make curved connections. Accessible and operative volume dampers should be used. Adjustable dampers should be provided with a means of indicating from the outside, the true position of the damper.
5. Access doors to ducts should be hinged and tightly fastened. Fire dampers in supply and vent ducts should be ⅛ in. steel plate, held by a fusible link for release at 160 deg. fahr.
6. Air intake should be screened with 1 in. mesh or less, at least No. 10 wire galvanized.
7. Final exit for exhaust discharges should be protected from the weather and pointed away from prevailing wind where possible.
8. Underground ducts should be water-proofed, provided with means of access for inspection and cleaning; also a drain connection trapped to sewer.
9. The use of varied metals and special finishes for different conditions encountered is of prime importance. The present day metal market affords wide range of choice, and a study of requirements for the individual application should be made.
10. Wherever water is present or condensation is likely to occur, galvanized iron sheets should be used.
11. When service encountered is severe and the material used may be subjected to rapid deterioration, either from abrasion or excessive corrosion, heavier gages of materials than ordinarily used are recommended.
12. In exposed work the same method of formation should be used throughout. All visible work should present a neat and workmanlike appearance.
13. The following table gives recommended gages of galvanized iron or steel sheets used for ducts, both rectangular and round:

ROUND DUCTS DIAMETER, IN.	GAGE U. S. STANDARD	RECTANGULAR DUCTS WIDTH, IN.
6 in. to 19 in.	No. 26 gage	4 in. to 18 in.
20 in. to 29 in.	No. 24 gage	19 in. to 30 in.
30 in. to 39 in.	No. 22 gage	31 in. to 60 in.
40 in. to 49 in.	No. 20 gage	61 in. to 118 in.
50 in. and above	No. 18 gage	120 in. and above

TABLE 3. CIRCULAR EQUIVALENTS OF RECTANGULAR DUCTS FOR EQUAL FRICTION

SIDE RECTANGULAR DUCT	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
8	6.9	7.6	8.2	8.8																
9	7.3	9.0	8.7	9.3	9.9															
10	7.7	8.4	9.2	9.8	10.4	11.0														
11	8.0	8.8	9.6	10.2	10.9	11.5	12.1													
12	8.3	9.2	10.0	10.7	11.4	12.0	12.6	13.2												
13	8.7	9.6	10.4	11.1	11.8	12.5	13.1	13.7	14.3											
14	8.9	9.9	10.8	11.5	12.3	12.9	13.6	14.3	14.9	15.4										
15	9.2	10.2	11.1	11.9	12.7	13.4	14.1	14.7	15.3	16.0	16.5									
16	9.5	10.5	11.4	12.3	13.1	13.8	14.5	15.2	15.8	16.5	17.1	17.6								
17	9.8	10.8	11.8	12.6	13.5	14.2	15.0	15.7	16.3	17.0	17.6	18.2	18.7							
18	10.0	11.1	12.1	13.0	13.8	14.6	15.4	16.1	16.8	17.4	18.1	18.7	19.2	19.8						
19	10.3	11.4	12.4	13.3	14.2	15.0	15.8	16.5	17.2	17.9	18.6	19.2	19.8	20.4	20.9					
20	10.5	11.6	12.7	13.6	14.5	15.4	16.2	17.0	17.6	18.4	19.0	19.7	20.3	20.9	21.5	22.0				
22	11.0	12.1	13.2	14.2	15.2	16.1	16.9	17.8	18.5	19.2	19.9	20.6	21.3	21.9	22.5	23.1	23.6	24.2		
24	11.4	12.6	13.8	14.8	15.8	16.8	17.6	18.5	19.3	20.0	20.8	21.5	22.2	22.8	23.5	24.0	24.7	25.2	25.9	26.4
26	11.8	13.1	14.3	15.4	16.4	17.3	18.3	19.2	20.0	20.8	21.6	22.3	23.0	23.8	24.4	25.1	25.7	26.3	26.9	27.5
28	12.2	13.5	14.8	15.9	17.0	18.0	19.0	19.8	20.7	21.5	22.4	23.1	23.9	24.6	25.3	26.0	26.6	27.3	27.9	28.5
30	12.6	13.9	15.2	16.4	17.5	18.5	19.5	20.5	21.4	22.2	23.1	23.9	24.7	25.4	26.2	26.8	27.5	28.2	28.8	29.5
32	12.9	14.3	15.6	16.9	18.0	19.1	20.1	21.1	22.0	22.9	23.8	24.6	25.4	26.2	27.0	27.7	28.4	29.1	29.8	30.5
34	13.2	14.7	16.1	17.3	18.5	19.6	20.7	21.6	22.6	23.5	24.4	25.3	26.2	26.9	27.7	28.5	29.2	30.0	30.7	31.3
36	13.6	15.1	16.4	17.7	19.0	20.1	21.2	22.2	23.2	24.2	25.1	26.0	26.8	27.7	28.5	29.3	30.0	30.8	31.5	32.2
38	13.9	15.4	16.8	18.2	19.4	20.6	21.7	22.8	23.8	24.8	25.8	26.7	27.5	28.4	29.2	30.0	30.8	31.5	32.3	33.1
40	14.3	15.7	17.2	18.6	19.8	21.1	22.2	23.3	24.4	25.4	26.4	27.3	28.2	29.1	29.9	30.8	31.6	32.4	33.1	33.9
42	14.5	16.1	17.6	19.0	20.3	21.6	22.7	23.8	24.9	25.9	26.9	27.9	28.8	29.8	30.7	31.4	32.2	33.0	33.8	34.5
44	14.8	16.4	18.0	19.4	20.7	22.0	23.1	24.3	25.4	26.5	27.5	28.5	29.5	30.3	31.2	32.1	32.9	33.7	34.5	35.3
46	15.1	16.7	18.4	19.8	21.1	22.4	23.6	24.8	25.9	27.0	28.1	29.1	30.1	31.0	31.9	32.8	33.8	34.6	35.4	36.2
48	15.4	17.0	18.7	20.1	21.5	22.8	24.1	25.2	26.4	27.5	28.6	29.6	30.5	31.6	32.5	33.4	34.3	35.2	36.1	37.0
50	15.7	17.3	19.0	20.4	21.9	23.2	24.5	25.7	26.9	28.0	29.2	30.3	31.3	32.2	33.1	34.1	35.0	35.9	36.8	37.6
52	15.9	17.6	19.2	20.8	22.2	23.6	24.9	26.2	27.4	28.5	29.6	30.7	31.8	32.9	33.8	34.7	35.6	36.5	37.4	38.3
54	16.1	17.9	19.6	21.1	22.6	24.0	25.3	26.6	27.8	29.0	30.1	31.2	32.3	33.4	34.4	35.3	36.3	37.2	38.0	38.9
56	16.3	18.2	19.9	21.5	22.9	24.4	25.7	27.0	28.3	29.5	30.6	31.7	32.8	33.9	34.9	35.9	36.9	37.8	38.7	39.6
58	16.6	18.4	20.2	21.8	23.3	24.7	26.1	27.4	28.7	30.0	31.1	32.2	33.3	34.4	35.4	36.4	37.4	38.4	39.4	40.3
60	16.8	18.7	20.4	22.1	23.6	25.1	26.5	27.8	29.1	30.5	31.6	32.7	33.8	34.9	36.1	37.1	38.1	39.1	40.0	40.9
62	17.0	19.0	20.7	22.4	24.0	25.5	26.9	28.2	29.5	30.9	32.1	33.2	34.3	35.4	36.6	37.7	38.7	39.6	40.6	41.6
64	17.3	19.2	21.0	22.7	24.3	25.9	27.3	28.6	29.9	31.3	32.6	33.7	34.8	35.9	37.1	38.2	39.2	40.2	41.2	42.2
66	17.5	19.5	21.2	23.0	24.6	26.2	27.7	29.0	30.3	31.7	33.0	34.2	35.3	36.4	37.6	38.7	39.8	40.8	41.8	42.8

TABLE 3. CIRCULAR EQUIVALENTS OF RECTANGULAR DUCTS FOR EQUAL FRICTION—(Continued)

SIDE RECTANGULAR DUCT	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	42	44	46	48
26	28.1	28.6																		
28	29.1	29.7	30.2	30.8																
30	30.1	30.7	31.3	31.9	32.5	33.0														
32	31.1	31.7	32.3	32.9	33.5	34.1	34.6	35.2												
34	32.0	32.7	33.3	33.9	34.5	35.1	35.7	36.3	36.8	37.4										
36	32.9	33.7	34.3	34.9	35.5	36.1	36.7	37.3	37.9	38.5	39.1	39.6								
38	33.8	34.6	35.3	35.9	36.5	37.1	37.7	38.4	39.0	39.5	40.1	40.7	41.2	41.8						
40	34.6	35.3	36.0	36.7	37.4	38.0	38.6	39.3	39.9	40.5	41.1	41.7	42.3	42.9	43.4	44.0				
42	35.2	36.0	36.8	37.6	38.3	39.0	39.6	40.3	40.9	41.5	42.1	42.7	43.4	44.0	44.5	45.1	46.2			
44	36.1	36.9	37.7	38.5	39.2	39.9	40.5	41.2	41.8	42.5	43.1	43.7	44.3	44.9	45.5	46.1	47.2	48.4		
46	37.0	37.8	38.5	39.3	40.0	40.8	41.5	42.2	42.9	43.5	44.2	44.8	45.4	46.0	46.6	47.2	48.4	49.5	50.6	
48	37.8	38.5	39.2	40.0	40.8	41.5	42.3	43.0	43.7	44.4	45.0	45.6	46.3	46.9	47.5	48.1	49.3	50.5	51.6	52.8
50	38.4	39.2	40.0	40.8	41.5	42.3	43.0	43.8	44.5	45.2	45.9	46.5	47.1	47.9	48.5	49.1	50.4	51.6	52.9	54.0
52	39.1	40.0	40.8	41.6	42.3	43.1	43.9	44.7	45.4	46.1	46.8	47.5	48.2	48.9	49.5	50.1	51.3	52.5	53.8	55.0
54	39.8	40.7	41.5	42.4	43.2	44.0	44.7	45.5	46.4	47.0	47.6	48.4	49.2	49.9	50.5	51.1	52.3	53.5	54.8	56.0
56	40.4	41.3	42.1	43.0	43.8	44.6	45.4	46.2	46.9	47.7	48.5	49.1	49.9	50.6	51.3	52.0	53.3	54.6	55.9	57.0
58	41.2	42.1	42.9	43.8	44.5	45.4	46.2	47.0	47.8	48.5	49.4	50.0	50.8	51.5	52.2	52.9	54.2	55.5	56.8	58.0
60	41.8	42.7	43.6	44.5	45.4	46.1	46.9	47.8	48.5	49.3	50.1	50.9	51.6	52.3	53.0	53.8	55.0	56.4	57.7	58.9
62	42.5	43.4	44.3	45.1	46.0	46.8	47.6	48.4	49.3	50.0	50.9	51.7	52.4	53.0	53.9	54.5	55.9	57.2	58.5	59.7
64	43.1	44.0	44.9	45.8	46.7	47.5	48.4	49.2	50.0	50.9	51.7	52.4	53.2	53.9	54.7	55.4	56.8	58.1	59.4	60.6
66	43.7	44.7	45.6	46.5	47.3	48.2	49.1	50.0	50.7	51.6	52.4	53.1	53.9	54.7	55.5	56.2	57.6	59.1	60.4	61.6
68	44.4	45.3	46.3	47.2	48.0	48.9	49.7	50.7	51.4	52.2	53.1	53.8	54.6	55.5	56.2	56.9	58.4	59.9	61.3	62.6
70	45.0	46.0	46.9	47.8	48.7	49.5	50.4	51.3	52.0	52.9	53.7	54.5	55.4	56.2	57.0	57.7	59.1	60.6	62.1	63.5
72	45.5	46.5	47.5	48.4	49.3	50.1	51.0	51.9	52.8	53.7	54.6	55.4	56.2	57.0	57.8	58.7	60.0	61.3	63.0	64.5

Table 3. Circular Equivalents of Rectangular Ducts for Equal Friction—(Continued)

Side Rectangular Duct	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
50	55.0																			
52	56.1	57.2																		
54	57.2	58.3	59.4																	
56	58.3	59.4	60.5	61.6																
58	59.3	60.5	61.6	62.7	63.8															
60	60.3	61.5	62.7	63.8	64.9	66.0														
62	61.3	62.5	63.7	64.8	66.0	67.1	68.2													
64	62.2	63.5	64.7	65.9	67.1	68.2	69.3	70.4												
66	63.2	64.4	65.7	66.9	68.1	69.3	70.4	71.5	72.6											
68	64.1	65.4	66.6	67.9	69.1	70.3	71.5	72.6	73.7	74.8										
70	65.0	66.3	67.6	68.8	70.1	71.3	72.5	73.7	74.8	75.9	77.0									
72	65.9	67.2	68.5	69.8	71.1	72.3	73.5	74.7	75.9	77.0	78.1	79.2								
74	66.8	68.1	69.4	70.7	72.0	73.3	74.5	75.7	76.9	78.1	79.2	80.3	81.4							
76	67.6	69.0	70.3	71.6	72.9	74.2	75.5	76.7	77.9	79.2	80.3	81.4	82.5	83.6						
78	68.4	69.8	71.2	72.6	73.9	75.2	76.4	77.7	78.9	80.2	81.4	82.5	83.6	84.7	85.8					
80	69.2	70.7	72.1	73.5	74.8	76.1	77.4	78.6	79.9	81.2	82.4	83.6	84.7	85.8	86.9	88.0				
82	70.1	71.5	73.0	74.4	75.7	77.1	78.4	79.6	80.9	82.1	83.4	84.6	85.8	86.9	88.0	89.1	90.2			
84	70.9	72.3	73.8	75.2	76.6	78.0	79.3	80.6	81.9	83.1	84.4	85.6	86.8	88.0	89.1	90.2	91.3	92.4		
86	71.7	73.2	74.6	76.0	77.4	78.9	80.3	81.5	82.9	84.0	85.3	86.6	87.8	89.0	90.2	91.3	92.4	93.5	94.6	
88	72.5	74.0	75.5	76.8	78.3	79.8	81.2	82.5	83.9	85.0	86.3	87.5	88.8	90.0	91.2	92.4	93.5	94.6	95.7	96.8
90	73.3	74.7	76.3	77.7	79.1	80.6	82.0	83.4	84.7	85.9	87.2	88.5	89.7	91.0	92.2	93.4	94.6	95.7	96.8	97.9
92	74.1	75.5	77.1	78.5	79.9	81.4	82.8	84.3	85.6	86.9	88.2	89.5	90.7	92.0	93.2	94.4	95.6	96.7	97.9	99.0
94	74.8	76.3	77.8	79.3	80.7	82.2	83.7	85.1	86.5	87.8	89.1	90.4	91.7	93.0	94.2	95.4	96.6	97.8	99.0	100.1
96	75.5	77.1	78.7	80.2	81.6	83.0	84.5	85.9	87.4	88.7	90.0	91.3	92.6	93.9	95.2	96.4	97.6	98.8	100.0	101.2

14. Methods of supporting and bracing rectangular ducts should be used so that sagging and buckling of sheets is entirely prevented. Hangers and angle iron-stiffeners are recommended for ducts over 36 in. wide at intervals of 4 ft. 0 in.

15. For public building work ducts should be thoroughly braced to prevent vibration of sides.

16. Longitudinal seams and transverse joints should be flat and smooth inside. Slip joints should be in the direction of air flow.

INSULATION FOR DUCTS

The overall heat resistance of metallic air ducts is very small and diminishes as the velocity of the air increases. Therefore, ducts used for carrying heated or cooled air should be insulated, if the maximum of efficiency in the delivery of air at the proper temperature at the outlets is desired.

Insulation is particularly important if it is desirous that the temperature of the spaces through which the ducts pass be not affected by the temperature of the air in the ducts.

For moderate temperatures, the flexible and rigid (board) forms of insulation, as well as corkboard, may be used satisfactorily. Generally not less than 1 in. of insulation should be used, and if the flexible type is installed, care should be exercised to avoid decreasing its thickness by compression, as the heat resistance will thereby be greatly reduced.

The joints of the insulation should be lapped, broken or sealed. If the flexible insulation is used, the joints should be lapped. If the rigid type of insulation is used, it should preferably be applied in two or more layers with the joints of each layer offset with respect to the preceding one. If corkboard is used and is applied in a single layer, the joints should be sealed.

The insulation may be attached with metal workers' screws or steel clips, or fastened in place with a spiral winding of copper wire with frequent stitches to prevent loosening in case of a broken wire. Canvas is frequently used to cover the insulation although this material is sometimes objectionable because of the fire hazard. Copper fly screen is sometimes used to fasten the insulation and to provide a protecting surface.

If the rigid type of insulation is used, the surface may be protected by the application of fireproofing paint directly to the insulation, thus obviating the necessity of any covering. Where the fire hazard is of less importance, any good lead and oil paint may be used and applied directly to the insulation after it has been sized, excepting in the case of flexible insulation. If the insulation is likely to be subjected to damage by traffic or other abuse, it should be properly protected. Heavy roofing is sometimes used for this purpose, and is also used for covering ducts placed out-of-doors.

If the duct carries hot gases or hot air, the insulation should be of the character used for steam and hot water pipes. This type of insulation usually comes in block form and may be wired to small rods placed about 6 in. apart around the periphery of the duct, parallel to its axis, the rods being held by structural tees or angles placed transverse to the duct, and which have holes in the flanges for engaging the rods.

CHAPTER 28

PNEUMATIC EXHAUST SYSTEMS

Types of Systems; Air Velocity; Size of Connections; Typical Layout; Design of Hoods; Conveyor Pipes; Fan Selection; Collectors.

PNEUMATIC exhaust systems may be classified by the economic purpose to be accomplished by the industries served, or by the type of system used.

Classifying exhaust systems by industries served, they fall in subdivisions such as metal working, woodworking, leather and shoe manufacturing, rubber industry, flint grinding, pottery works, pulverizing works, celluloid manufacturing, printing establishments, felt hatting and fur manufacturing, textile mills, grain and cereal industry, etc.

TYPES OF SYSTEMS

The type of exhaust system to be used is determined by the industry served, kind of material handled, and the work to be accomplished. There are two general arrangements, the central and the group systems. In the central system a single or double fan is located near the center of the shop with a piping system radiating to the various machines to be served. In the group system, which is sometimes employed where the machines to be served are widely scattered, small individual exhaust fans are located at the center of the machine groups.

The group arrangement has the advantage of flexibility.

Exhaust systems are also classified by the means employed to collect dust or other material handled. The dust or refuse may be collected and controlled by enclosing hoods, open hoods, inward air leakage or by exhausting the general air of the room.

With some classes of machinery it is not feasible to closely hood the machines and in these cases open hoods over or adjacent to the machines are provided to collect as much as possible of the dust and fumes. In this class come such machines as rubber mills, package filling machinery, sand blast, crushers, forges, pickling tanks, melting furnaces, and the unloading points of various types of conveyors.

The open hoods should be placed as close to the source of dust or fumes as possible, with due regard to the movements of the operator.

When the hood has to be placed at some distance above the machine it should be large enough to encompass an area of considerable extent as diffusion is usually quite rapid.

Consideration must also be given to the natural movement of the fumes. For those that are lighter than air the hood should be over or above the machine and where a heavy vapor or dust-laden air at ordinary temperature is to be removed, horizontal or floor connections are required. If it is attempted to remove heavy dust such as lead oxides by an overhead hood the conditions may be worse than if no exhaust were used at all, owing to the rising air current carrying the dust up through the breathing zones. The principle to keep in mind in all cases is to take advantage of the natural tendency of the material to move upward or downward.

In another class of operation the main object is to prevent the escape of dust into the surrounding atmosphere, the removal of some dust from the machine or enclosure being merely incidental. The dust-creating apparatus is enclosed within a housing which is made as tight as practicable, and sufficient suction is applied to the enclosure to maintain an inward air leakage, thus preventing escape of the dust. While the exhaust system is only required to handle the air which leaks in through the crevices and openings in the enclosure, yet in many installations leakages are very high and great care is required to obtain satisfactory results with a system of this kind. The inward-leakage principle is utilized for controlling dust in the operating of tumbling barrels, grinding, screening, elevating and similar processes.

Certain dust and fume producing operations are best carried on by isolating the process in a separate compartment or room and then applying general ventilation to this space. The compartment or room in which the work is performed should be as small as is consistent with convenience in handling the work. The ventilating system should be designed so that a strong current of clean air is drawn across the operator, and away from him toward the work, where the dust is picked up and carried from the room.

IMPORTANT REQUIREMENTS FOR AN EFFICIENT SYSTEM

It is impracticable to enumerate all of the requirements for an efficient exhaust and collecting system; however, among the more important are the following:

1. Fans, collectors, hoods, and ducts should be of adequate size.
2. Air volume and velocities should be adequate for the work to be accomplished.
3. The exhaust hoods should not interfere with the operation of the machine or with access to its working parts.
4. The system should not increase the fire hazard.
5. The system should not increase the dust explosion hazard.
6. Where power is expensive, it should do the required work with a minimum power consumption.
7. In cold climates, it should not remove any more air than necessary from the building.
8. Where power is comparatively cheap, first cost should be low, even if the power required to operate is slightly higher.

The first step in designing systems employing hoods to trap the material is to determine the number and size of the connections for each individual machine. At this point the designer's past experience is of great value, as, while it is possible to set certain general standards, yet in actual practice the sizes are considerably affected by the local conditions which the layout man finds in the field, and he bases the pipe sizes and hoods on his judgment, being guided by his experience and the general practice.

The size of hoods and connections are determined by the size and type of machines or apparatus to be handled by the exhaust system, by the kind of material worked, by the duty of the machines and by other local conditions. It is impracticable to lay down any general rules for determining size connections for the various types of machines and Tables 1 to 3, giving sizes as used in some of the common industries are only intended to serve as a general guide. Under certain favorable conditions smaller connections may be supplied.

Open bottom exhaust hoods of the canopy type, where it is impractical to enclose completely the point of origin of the dust or fumes, should extend over the machine or operation at least 12 in. in every direction if the hood is not elevated more than 2 ft. For each additional 2 ft. of elevation, the size of the hood should be increased at least 12 in. in all directions.

It is desirable to make the area of the connecting pipe not less than one-fifteenth of the total hood area.

In systems employing inward air leakages the area of connections must be proportional to total leakage area in the enclosing housing.

Tumbling barrels have connections ranging from 4 to 8 in., bucket conveyors 6 to 12 in., and screening machines 6 to 10 in.

In general room exhaust, large connections should be provided so that the air may be handled at low velocity and with a minimum power consumption.

After having determined on the proportions of the exhaust system as regards hoods and connections it is then necessary to choose the air velocity or suction at the hood connections; suction at the hood connections being a measure of the air velocity at that point.

AIR VELOCITY REQUIRED

The air velocity required is dependent upon the specific gravity of the material, the fineness of the particles, and their physical characteristics. Certain materials such as grease wools, silk waste, salt, and other hydroscopic substances are difficult to handle due to the tendency to deposit in the conveyor pipes.

While the velocity in the system should be sufficiently high to insure the removal of the material, it should be kept as low as practicable since any higher velocity requires the use of unnecessary power. With a fixed system or orifice the power increases as the cube of the increase in velocity; or for the same quantity of air and material handled, inversely as the fifth power of the diameter of round ducts.

Velocities commonly employed are: 2,500 to 3,000 ft. per minute for light dusts, cotton, shavings and sawdust from dry wood, and similar substances. Heavy dusts, wool, shavings and sawdust from wet wood, rags, waste paper and similar materials 3,000 to 4,000 ft. per minute. Lead dust, hog waste, pulp chips, etc., 4,000 to 6,000 ft. per minute.

In choosing the pipe sizes consideration must be given to the manner in which the machines will be operated, as in case a considerable number of machines, all discharging into one main, should be shut off at the same time, the velocity in the main might easily be lowered to the point where it would not be sufficient to carry the material from the machines still in operation, and thus result in clogging the pipes. Accordingly, it is sometimes desirable to use velocities higher than the minimum to allow a factor of safety to cover this contingency.

In some states codes have been issued specifying suctions to be maintained for the more common dusts.

A suction standard should always be considered in conjunction with the shape of hood, and size connection, as these factors together determine the volume of air exhausted and its velocity, which in turn are a measure of the effectiveness of the exhaust system.

TABLE 1. SIZE OF CONNECTIONS FOR WOOD-WORKING MACHINERY

TYPE OF MACHINE	DIAMETER OF CONNECTIONS IN INCHES
Circular Saws, 12-in. diam.	4
Circular Saws, 12-24-in. diam.	5
Circular Saws, 24-40-in. diam.	6
Band Saws, Blade under 2 in. wide	4
Band Saws, Blade 2-3 in. wide	5
Band Saws, Blade 3-4 in. wide	6
Band Saws, Blade 4-5 in. wide	7
Band Saws, Blade 5-6 in. wide	8
Small Mortisers	6
Single End Tenoners	6
Double End Tenoners	7
Double End, Double Head Tenoners	10
Planers, Matchers, Moulders, Stickers, Jointers, etc.—	
With Knives, 6-10 in.	5–6
With Knives, 10-20 in.	6–8
With Knives, 20-30 in.	6–10
Shapers, Light Work	4–5
Shapers, Heavy Work	8
Belt Sander, Belt less than 6 in. wide	5
Belt Sander, Belt 6-10 in. wide	6
Belt Sander, Belt 10-14 in. wide	7
Drum Sander, 24 in.	5
Drum Sander, 30 in.	6
Drum Sander, 36 in.	7
Drum Sander, 48 in.	8
Drum Sander, over 48 in.	10
Disc Sander, 24 in. diam.	5
Disc Sander, 26-36 in. diam.	6
Disc Sander, 36-48 in. diam.	7
Arm Sander	4

The volume of air of standard density taken into the system at each connection is given by the formula:

$$Q = 4{,}000\, A\, f \sqrt{i} \qquad (1)$$

where

Q = cubic feet of air per minute.
A = area of connection in square feet.
f = orifice or restriction coefficient.
i = static suction measured in inches of water.

TABLE 2. SIZE OF CONNECTIONS FOR GRINDING AND BUFFING WHEELS

DIAMETER OF WHEELS	MAX. GRINDING SURFACE SQ. IN.	MIN. DIAM. OF BRANCH PIPES IN INCHES
Grinding—		
6 in. or less, not over 1 in. thick	19	3
7 in. to 9 in., inclusive, not over 1½ in. thick	43	3½
10 in. to 16 in., " " " 2 in. "	101	4
17 in. to 19 in., " " " 3 in. "	180	4½
20 in. to 24 in., " " " 4 in. "	302	5
25 in. to 30 in., " " " 5 in. "	472	6
Buffing—		
6 in. or less, not over 1 in. thick	19	3½
7 in. to 12 in., inclusive, not over 1½ in. thick	57	4
13 in. to 16 in., " " " 2 in. "	101	4½
17 in. to 20 in., " " " 3 in. "	189	5
21 in. to 27 in., " " " 4 in. "	338	6
27 in. to 33 in., " " " 5 in. "	518	7

The orifice coefficient f is dependent upon the shape and construction of the hood and will range from 60 to 90 per cent. An average value is 70 per cent.

Knowing the suction at each hood and the diameter of each connection, the volume of air passing up each branch can be taken from Table 4. The sum of all these volumes gives the total volume to be handled by the exhaust fan.

Common practice is to provide a main suction pipe having an area 20 to 25 per cent in excess of the sum of the areas of the branches entering it between the point in question and the dead end of the main. Similarly the discharge pipe leading from the fan outlet to the collector is frequently made the same diameter as the large end of the main suction pipe. The reason for this increase in size is that a considerable power saving results from the lower air velocity. However, there is no technical reason why

TABLE 3. SUCTION PRESSURES REQUIRED AT HOODS FOR CONNECTIONS OF USUAL PROPORTIONS

	STATIC SUCTION IN INCHES OF WATER
Exhausting from grinding and buffing wheels	2
Exhausting from tumbling barrels	2
Exhausting from wood-working machinery—light duty	2
Exhausting from wood-working machinery—heavy duty	2–4
Shoe machinery exhaust	2–3
Exhausting from rubber manufacturing processes	2
Flint grinding exhaust	2
Exhausting from pottery processes	2
Lead dust and fume exhaust	2–4
Fur and felt machinery exhaust	2–3
Exhausting from textile machinery	2–3
Exhausting from elevating and crushing machinery	2
Conveying bulky and heavy materials	3–5

mains should be a certain percentage greater area than the sum of the connections, and still lower power consumption can be obtained by using larger branches and mains of equal area. While the rule of thumb method of determining size of mains works very well in many cases, yet it is always desirable to figure the mains and branches of the proper size to give the velocity which has been found best suited to the work to be done.

In certain special cases where explosive or poisonous dusts such as aluminum buffings, grain dust, powdered sugar, or lead dust are handled, increasing the size of the mains unduly would introduce a serious hazard.

TABLE 4. CUBIC FEET OF AIR HANDLED PER MINUTE THROUGH AVERAGE COLLECTING HOODS

Based on Coefficient of Orifice of 0.71 with 10 Per Cent Added for Leakage

DIAMETER OF CONNECTION PIPE IN.	MAINTAINED SUCTION—IN. WATER GAGE						
	1	1½	2	2½	3	4	5
1½	38	47	54	61	67	76	86
2	68	84	97	108	118	136	153
2½	107	131	161	168	185	214	238
3	153	188	217	243	266	306	343
3½	209	256	296	330	362	418	466
4	273	334	386	431	473	546	609
4½	345	423	488	546	598	690	775
5	427	523	605	676	741	854	955
6	614	751	867	970	1062	1228	1373
7	835	1023	1181	1322	1448	1670	1870
8	1092	1337	1546	1727	1892	2184	2440
9	1381	1694	1953	2184	2387	2762	3091
10	1705	2090	2409	2695	2959	3410	3806

The maintained resistance of the exhaust system is composed of three factors: (1) loss through the hoods; (2) collector drop; and (3) friction drop in the pipes.

The collector drop in inches of water is given roughly by equation (2) but where possible the resistance of the particular collector to be used should be ascertained from the manufacturer as these resistances differ quite widely.

$$\text{Drop} = C\left(\frac{V}{1{,}000}\right)^2 \qquad (2)$$

where

C = a constant which depends upon the type of collector and ranges from 0.065 to 0.145.

V = velocity in feet per minute of air entering the collector.

Friction drop in the pipes must be computed for each section where there is a change in area or in velocity. Find the velocities in each section of pipe starting with the branch most remote from the fan. The friction drop for these sections can be determined by reference to Table 5. Total friction loss in the piping system is the friction drop in the most remote branch plus the drop in the various sections of the main, plus the drop in the discharge pipe.

TABLE 5. FRICTIONAL RESISTANCE OF STRAIGHT CONVEYOR PIPE

To Flow of Air Per 100 Feet of Pipe

VEL. OF AIR IN FT. PER MIN.	LOSS OF PRESSURE IN INCHES FOR GIVEN DIAMETER PIPE						
	4″	5″	6″	7″	8″	10″	12″
2000	1.92	1.53	1.28	1.09	0.962	0.770	0.640
2200	2.32	1.85	1.55	1.32	1.16	0.932	0.778
2400	2.77	2.22	1.84	1.58	1.39	1.01	0.924
2600	3.26	2.60	2.17	1.86	1.63	1.30	1.08
2800	3.76	3.01	2.52	2.15	1.89	1.51	1.26
3000	4.33	3.46	2.88	2.47	2.08	1.73	1.44
3200	4.93	3.94	3.28	2.82	2.47	1.97	1.64
3400	5.56	4.45	3.71	3.18	2.78	2.22	1.85
3600	6.23	4.98	4.15	3.56	3.12	2.49	2.08
3800	6.95	5.55	4.62	3.97	3.48	2.78	2.32
4000	7.69	6.15	5.13	4.40	3.85	3.08	2.57
4200	8.48	6.78	5.65	4.85	4.25	3.49	2.83
4400	9.26	7.41	6.18	5.30	4.63	3.71	3.09
4800	11.05	8.85	7.38	6.32	5.55	4.43	3.69
5200	13.00	10.50	8.66	7.44	6.50	5.21	4.34
5600	15.25	12.05	10.05	8.61	7.55	6.03	5.05
6000	17.30	13.85	11.52	9.89	8.66	6.92	5.76
	14″	16″	18″	20″	22″	24″	30″
2000	0.550	0.482	0.428	0.385	0.350	0.320	0.257
2200	0.655	0.582	0.578	0.465	0.423	0.388	0.310
2400	0.790	0.693	0.617	0.553	0.504	0.462	0.369
2600	0.930	0.810	0.722	0.650	0.590	0.542	0.434
2800	1.07	0.932	0.838	0.754	0.685	0.628	0.503
3000	1.24	1.08	0.961	0.865	0.788	0.722	0.577
3200	1.41	1.23	1.09	0.985	0.895	0.820	0.657
3400	1.59	1.43	1.24	1.11	1.01	0.925	0.742
3600	1.78	1.56	1.38	1.25	1.13	1.04	0.832
3800	1.99	1.74	1.54	1.39	1.26	1.16	0.926
4000	2.20	1.92	1.71	1.54	1.40	1.28	1.03
4200	2.43	2.12	1.88	1.70	1.54	1.42	1.13
4400	2.66	2.33	2.06	1.85	1.68	1.54	1.24
4800	3.17	2.77	2.46	2.22	2.02	1.85	1.48
5200	3.72	3.25	2.89	2.61	2.36	2.16	1.75
5600	4.32	3.78	3.35	3.02	2.74	2.52	2.01
6000	4.95	4.33	3.85	3.46	3.14	2.89	2.31

FRICTIONAL RESISTANCE OF ELBOWS

Elbows having a throat radius equal to the pipe diameter set up a resistance equivalent to a section of straight pipe approximately 10 diameters long. With a throat radius of 1½ times the diameter the resistance is about the same as seven diameters of straight pipe.

TABLE 6. DIAMETERS OF BRANCH PIPES AND CALCULATIONS OF MAIN FOR TYPICAL EXHAUST SYSTEM ILLUSTRATED IN FIG. 1

MACHINE	DIAMETER OF BRANCH PIPES	AREA SQ. INCHES	TOTAL LOAD AREA SQ. INCHES	TOTAL LOAD AREA SQ. INCHES + 25%	SECTION OF MAIN	DIAMETER OF MAIN IN EVEN INCHES
Rip Saw	5 in.	19.6	19.6	25	*B*	6 in.
Cut-off Saw	4 in.	12.6	32.2	40	*C*	7 in.
Band Saw	5 in.	19.6	51.8	65	*D*	9 in.
Planer Top Connection	6 in.	28.3	80.1	100		
Planer Bottom Connection	6 in.	28.3	108.4	135	*E & F*	13 in.

TYPICAL LAYOUT AND CALCULATIONS

To illustrate the method of laying out and calculating the elements of an exhaust system, assume a small wood-working shop, having one 16 in. diameter rip saw, one 12 in. diameter cut-off saw, one band saw with 2 in. blades, and one planer with 10 in. knives, and with the general arrangement of the machines and exhaust system as shown in Fig. 1.

First, determine the sizes to be used for the branch connection to the hoods. These sizes can be taken from Table 1 giving due consideration to the type and size of machines as well as the class of work handled. (See Table 6).

The next step is to determine the size of the main, which varies in diameter, increasing from its dead end towards the fan, as necessitated by the branch pipes entering it. Its exact diameter at any point is determined according to the following rule:

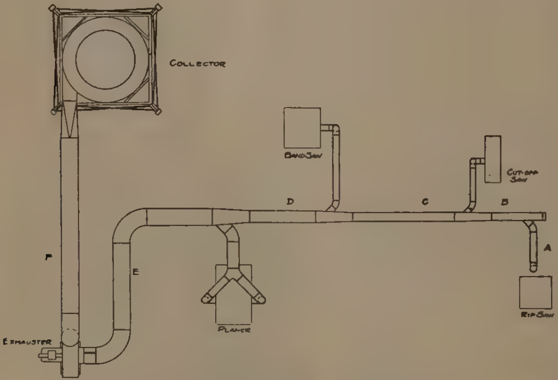


Fig. 1. Typical Exhaust System

The area of the main at any point should be 20 per cent to 25 per cent in excess of the sum of the areas of the branches entering it between the point in question and the dead end of the main. Floor sweeps, if equipped with efficient blast gates, need not be included in computing the area of the main.

According to Table 3, 2 in. suction at the hoods is suitable for exhausting from wood-working machinery where the duty is light, as would be the case in this problem.

The volume of air to be handled by the system is determined from Table 4.

1 to 5 in. connection, 2 in. suction, (from Table 4) 605 × 1 equals	605 c.f.m.
1 to 4 in. connection, 2 in. suction, (from Table 4) 386 × 1 equals	386 c.f.m.
1 to 5 in. connection, 2 in. suction, (from Table 4) 605 × 1 equals	605 c.f.m.
2 to 6 in. connection, 2 in. suction, (from Table 4) 867 × 2 equals	1,734 c.f.m.
Total	3,330 c.f.m.

The next step in the calculations is to determine the maintained resistance of the system, which corresponds to the static pressure that the exhaust fan must produce to obtain the proper volume of air and suction at the hoods.

This maintained resistance is composed of the following elements:

1. Loss through the hoods. This is usually assumed as equal to the suction maintained at the hoods, in this problem 2 in.

2. Frictional resistance or loss in piping system. This is a function of the pipe diameter and the velocity of flow and accordingly it is necessary to compute the friction for each section and to add the components together.

3. Pressure drop or loss through the collector. For an exhaust system such as the one under consideration it is customary to choose a collector having an inlet of the same, or slightly greater, diameter than the main discharge pipe leading to the collector.

The friction per 100 ft. of length for various pipe diameters and velocities can be read from Table 5.

Table 7. Details of Calculation of Friction of Piping System Illustrated in Fig. 1

Section of Piping	Effective Length of Pipe Taken As:	Diameter of Pipe in Inches	Area of Pipe in Sq. Ft.	C. F. M.	Velocity of Air Flow, Feet per Minute	Friction per 100 ft. of Length	Pipe Friction
A	20 ft.	5	0.136	605	4450	7.4	1.48
B	10 ft.	6	0.195	605	3100	3.1	0.31
C	10 ft.	7	0.267	991	3700	3.8	0.38
D	15 ft.	9	0.442	1,596	3600	2.8	0.42
E	20 ft.	13	0.922	3,330	3600	2.0	0.40
F	25 ft.	13	0.922	3,330	3600	2.0	0.50
Total pipe friction							3.49

The friction for intermediate pipe sizes not given in the table can be computed from the table values, from the relation that the friction in two pipes, the velocity remaining constant, is inversely proportional to the ratio of the diameters. This can be written:

$$z_2 = z_1 \frac{d_1}{d_2} \tag{3}$$

z_1 = friction in pipe of d_1 diameter.
z_2 = friction in pipe of d_2 diameter.

The total pipe friction is calculated to be 3.49 in. of water. The individual steps in the calculation are given in Table 7.

The effective length of pipe is determined by adding to the actual length a sum to compensate for the effect of elbows as given in the note at the bottom of Table 5.

In this problem the main discharge pipe is 13 in. in diameter and a collector having a 14 in. inlet is selected. The area of the collector inlet is 1.069 sq. ft.

Velocity at collector inlet:

$$V = \frac{3{,}330}{1.069} = 3{,}120$$

$$\text{Collector Drop} = C\left(\frac{V}{1{,}000}\right)^2$$

$$= 0.145\left(\frac{3{,}120}{1{,}000}\right)^2 = 1.4 \text{ in. of water.}$$

TABLE 8. TOTAL RESISTANCE OF THE SYSTEM SHOWN IN FIG. 1

1. Loss at hoods	2.00 in. of water
2. Loss through piping	3.49 in. of water
3. Loss at collector	1.40 in. of water
TOTAL resistance of system	6.89 in. of water

The total resistance of the system as indicated in Table 8 is 6.89 in. of water. Therefore an exhaust fan to handle 3,330 c.f.m. at 7 in. static pressure will be required.

SELECTING THE FAN

The usual types of ventilating fans are unsuitable for exhaust systems which are required to handle materials such as shavings, sawdust, emery dust, etc. Higher pressures are required than in ventilating work and in addition housings and blast wheel must be so constructed that the materials handled do not deposit in them. While the fans used in different exhaust systems are more or less of the same general type, modifications are frequently necessary to fit them for handling such materials as long shavings, strips of paper, cotton, pulverized coal, etc.

Where considerable quantities of explosive dust or inflammable materials pass through the exhaust fan, the blast wheel should be constructed of brass composition, copper or other soft metal and in all cases ample clearance should be provided between blast wheels and housings.

Where stringy or fibrous material is to be handled through the fan, a fan wheel especially designed for that purpose should be employed.

For further data on the selection of fans, see Chapter 26.

COLLECTORS

The most common method of separating the dust and other materials from the air is to pass the mixture through a centrifugal or "cyclone" collector. In this type of collector the mixture of the air and material is introduced on a tangent, near the cylindrical top of the collector, and the whirling motion sets up a centrifugal action causing the comparatively heavy materials suspended in the air to be thrown against the side of the separator, from which position it spirals down to the tail piece, while the air escapes through the stack at the center of the collector.

For most systems, the inlet size of the collector may be the same as the diameter in inches of the main pipe leading to it. The larger the collector within certain limits the better will be the separation, and the less will be the back pressure on the fan and the power consumed.

Special construction is sometimes required for fine dust, also some blow-pipe manufacturers use a special type of collector for furnace feed, the object being to deliver the material to furnaces as uniformly as possible.

When more than one fan delivers into a single collector a back pressure valve is required to prevent one fan blowing back through the other in case the second fan should stop for any reason.

In most plants, where wood refuse is used for fuel, it is delivered by gravity directly from the collector to the furnace. The discharge pipe leading from the bottom of the collector is divided and the junction is furnished with a switch or valve so arranged that when the material comes too fast for the fires it can be diverted into a reserve bin.

The furnace feeder should be hinged where it is attached to the lower end of the discharge pipe, in order that it may be disconnected from the furnace when the fan is shut down. Also great care must be taken to provide an absolutely tight switch. Otherwise, when discharging refuse to the storage bin, fine sawdust will sift through this valve and settle in the furnace feed pipe, and, in case the fireman has neglected to disconnect the feeder from the furnace, the flame may flash back, following this train of fine sawdust, into the collector.

Other forms of collectors or separators are: settling chambers, cloth screen and bag collectors, bag houses, air washers and electric precipitators.

DESIGN OF HOODS

If the material to be moved is already in motion, as are the chips thrown off from wood-working machines, the hoods should be arranged in the path of the particles so that the velocity of the particles assists the air in carrying the material to the throat of the hood.

Hoods should be arranged to draw dust and fumes away from the face of the operator. They should be placed as close as possible to the source of dust or waste material and wherever practical, the hoods should entirely enclose the dust producing operation.

Hoods are usually constructed of galvanized sheet iron or other equally substantial and durable material. The material should be heavy enough to withstand the abrasive action of the dust and refuse. The hoods should be of sufficient mechanical strength to keep their shape and should be well braced and substantially supported. Galvanized iron used should never be lighter than No. 22 gage.

If acid or corrosive fumes are present heavy material painted with acid resisting paint should be used, or the hoods may be made of non-corrosive material.

The exposed edges of all sheet metal hoods should be bound with wire or band iron, not only to give the necessary stiffness, but also to prevent the operator from being cut by the raw edges of the sheets.

CONVEYOR PIPES

The conveyor pipes leading from the hoods to the fan and thence to the collector are commonly made of galvanized iron, the gage of which varies from No. 24 to 14, depending upon the diameter. The piping should be free from dents, fins and projections of all kinds on which refuse material might catch.

All permanent circular joints should be lap-jointed, riveted and soldered, and all longitudinal joints either grooved and locked or riveted and soldered. Circular laps should be in the direction of the flow, and piping installed out-of-doors should not have the longitudinal laps at the bottom. Every change in pipe size should be made with an eccentric taper flat on the bottom, the taper to be at least 5 in. long for each inch change in diameter.

All pipes passing through roofs should be equipped with collars so arranged as to prevent water leaking into the building.

The main trunks and branch pipes should be as short and straight as possible, strongly supported, and with the dead ends capped to permit inspection and cleaning. All branch pipes should join the main at an acute angle, the junction being at the side or top and never at the bottom of the main. Branch pipes should not join the main pipes at points such that the material from one branch tends to enter the branch on the opposite side of the main.

Cleanout openings having suitable covers should be placed in the main and branch pipes so that every part of the system can be easily reached in case the system clogs. Either a large cleanout door should be placed in the main suction pipe near the fan inlet, or a detachable section of pipe, held in place by lug bands, may be provided.

Elbows should be made at least two gages havier than straight pipe of the same diameter, the better to enable them to withstand the additional wear caused by changing the direction of flow. They should preferably have a throat radius of at least one and one-half times the diameter of the pipe.

Every pipe should be kept open and unobstructed throughout its entire length, and no fixed screen should be placed in it, although the use of a trap at the junction of the hood and branch pipe is permissible, provided it is not allowed to fill up completely.

The passing of pipes through fire-walls should be avoided wherever possible, and sweep-up connections should be so arranged that foreign material cannot be easily introduced into them.

MAINTENANCE OF SYSTEM

Because of its simplicity the exhaust system usually receives but little attention once it is installed; however, to obtain the best results, it should be inspected at suitable intervals and necessary adjustments made.

The exhaust fan should be given proper attention the same as any other high-speed machine. It should be kept in proper alignment and tightly bolted to its foundation.

Suction hoods, which have been removed to adjust the machines, should be replaced as soon as the adjustments are completed.

Never start a machine with the blast gate closed, as the slight air leakage past the blast gate may draw material into the pipe and clog it.

Disconnect furnace feeders from the furnaces when not in operation, and do not overload the system by ill-advised additions.

CHAPTER 29

DRYING BY EVAPORATION

Definitions; Methods of Drying; Types of Dryer Construction; Mechanism of the Drying; Control of the Drying Operation; Dryer Design; Dryer Arrangement and Construction; Experimental Technique.

DEFINITION OF TERMS

THE term drying, in its broader sense, refers to the removal of water or other volatile liquid from a gaseous liquid, or solid material. Except in the case of solids, the term is not ordinarily used unless the water or other liquid removed is present in a relatively small amount. In a more restricted sense, drying is the removal of water by vaporization from a non-volatile liquid or solid. This chapter deals with drying thus defined.

Where the solid material to be dried contains large amounts of free water, the actual drying process is frequently preceded by the removal of part of the water by filtration, settling, pressing, centrifuging, or other mechanical means. Removal of as much water as possible by such methods is usually advisable, as the cost of these operations, per pound of water removed, is in general much less than by vaporization.

METHODS OF DRYING

Classification of Methods According to Heat Supply

Drying methods may be classified basically in accordance with the means by which heat is supplied to the material to be dried. Thus, in some cases, as in *air current dryers*, the heat of vaporization is transferred to the material from the atmosphere surrounding it. In *natural air dryers*, this heat is merely the sensible heat of the outdoor atmosphere; while in so-called *artificial air dryers* heat is added to the air by means of radiators or the addition of a heated gas such as superheated steam or products of combustion, the air being almost entirely displaced by such gases in some drying processes. Where products of combustion can be used, a particularly high overall efficiency of the dryer is possible.

In other types of dryers, known as *contact dryers*, heat is supplied by direct contact between the material and a heated surface such as a pan or shelf, such surfaces being heated by products of combustion, steam, hot water, heated oil, electrical resistance, or latent heat of condensation. In both air dryers and contact dryers, additional heat may be supplied by direct radiation from hot surfaces which are *in sight* of the material. In the *sun drying* of raisins and other fruits, this radiant heat comes from the sun, while in artificial dryers it is derived from heated surfaces such as steam coils.

Radiant Heat

Radiant heat can at best supply only a portion of the total heat of vaporization. About one-third to one-half of the heat given off by a radiating surface passes through the air to the object which is to be dried without materially raising the temperature of the intervening air. The remaining portion of the heat from the radiator warms the air by convection and produces warm air currents which in turn transfer their heat to the material. A given amount of heat can be supplied to the material by means of heated air currents with only one-tenth to one-fifteenth as much radiating surface as would be required if this same quantity of heat were to be transferred by direct radiation. Direct radiation is, therefore, only an incidental source of heat in most dryers, except in the drying of certain kinds of material where the advantages of radiant heat will offset the higher first cost of the equipment. In vacuum dryers radiant heat is particularly useful in the drying of some bulky solids, owing to the difficulty of transferring heat to the material by means of rarified air currents at extremely low pressures.

Continuous and Intermittent Operation

Dryers may be operated continuously or intermittently. In the continuous type, the material is fed in at one end of the dryer and discharged at the other end when dry. The movement may be either a steady flow, or may consist of the periodic or progressive removal of a minor portion of the charge at one end of the dryer and the admission of a like portion at the other end, at more or less regular intervals. Dryers of the intermittent type, often called charge dryers, are filled at the start with the material to be dried and are emptied again when the drying is completed, after which the process is repeated. The material in charge dryers is usually stationary but is sometimes shifted in position periodically or kept in continuous motion within the dryer for greater uniformity and speed of drying.

With constant rates of flow of air and material, continuous dryers are usually simple to control and can be fitted advantageously into the train of manufacturing operations with minimum loss of time and requirements for storage and handling. Charge dryers, on the other hand, permit the use of complicated schedules of temperature and humidity which would be difficult to attain with continuous operation, and they have the important advantages of simplicity and low first cost, making them particularly adapted to small installations and experimental work.

Temperature and humidity conditions in a charge dryer should be substantially uniform throughout the dryer, in order to produce uniform drying throughout the charge and prevent injury to the material. These conditions may remain uniform throughout the drying cycle or may be changed periodically as the drying progresses. In continuous or progressive dryers, the drying conditions usually vary from one end of the dryer to the other, either to suit the varying requirements of the different stages of drying or because of different rates of evaporation at different positions in the dryer. With some materials the highest temperatures and lowest humidities are used at the charging end of the dryer and with others, particularly bulky, plastic materials like lumber and clay, the most severe conditions are called for at the discharge end with gradually lower temperatures and higher humidities toward the end where the fresh material enters. Some continuous dryers maintain an approximately uniform drying condition from one end to the other, where the path of travel is short and the water can be quickly and easily evaporated.

A higher heat efficiency is usually obtained with a continuous dryer than with a charge dryer, particularly where a counter current flow of air and material is possible. The air in a charge dryer must be changed frequently in order to maintain uniform conditions and to prevent the accumulation of evaporated moisture. This means that only a small part of the heat in this air can be utilized for drying. To conserve as much heat as possible, the air in charge dryers is often recirculated through the material after reheating and removal of surplus moisture by condensation or mixture with fresh outside air. On the other hand, in continuous dryers of the counter-current type, a large part of the heat of the air passing through the dryer can be utilized in evaporation, since the air can enter at the discharge end in a hot-dry condition and emerge at the charging end in a condition approaching saturation.

Low and High Temperature Drying

The division line between what is known as low-temperature drying and high-temperature drying is, roughly speaking, the boiling point of water under ordinary atmospheric conditions. In high-temperature drying, the temperatures range from 212 to 1,000 deg. fahr. or more. Under these conditions, all of the water in the material will vaporize quickly and the humidity of the air becomes of minor importance. High-temperature drying is usually faster and more economical of heat than low-temperature drying, but often cannot be used because many materials, particularly foods and other organic substances, are injured or destroyed by temperatures above the boiling point. For such materials low-temperature drying is required, the drying being produced by supplying enough heat to the material, and surrounding it with a sufficiently low humidity, so as to produce a higher vapor pressure within the material at its surface than is present in the air surrounding it. As long as this difference in vapor pressure is maintained, the drying will proceed until completed.

In drying with temperatures above the boiling point, the vehicle used may be gas, such as products of combustion, air, or the vapor of the water being evaporated, *i.e.*, superheated steam. It is important, in high temperature drying, to remove products of oxidation as well as explosive and inflammable gases as quickly as possible, by means of ample circulation. Agitator fans within the dryer are often used in high-temperature work to create the necessary velocity for close contact with the material without moving an excessive volume of air or gas through the dryer. Static electricity, which sometimes accumulates in high-temperature drying because of the low humidities, making powders and fabrics difficult to handle, may often be controlled by a small steam spray. Many materials dried at high temperatures are soft when removed from the dryer and must be hardened in air that is warm enough and dry enough to prevent sweating and moulding. Within the critical limits, many materials produce better results if dried quickly at comparatively high temperatures than if dried more slowly at lower temperatures.

Vacuum Drying

It is sometimes advantageous to conduct the drying in a partial vacuum, in order to obtain rapid vaporization at comparatively low temperatures. This method is especially useful for materials which are sensitive to heat, such as valuable food products which must be dried rapidly at low temperatures in order to preserve flavors and prevent harmful organic changes. A vacuum as high as 28 in. of mercury is sometimes used where a very low boiling point is desired, but the usual range is from 12 to 20 in.

In vacuum drying heat is supplied to the material either by contact with the heated walls or shelves of the container, which is the usual method, or by direct radiation, either from the walls or shelves or from special radiators. Some materials containing only 2 to 3 per cent moisture are first heated before being put in the vacuum chamber. When the vacuum is established, the heat already in the material vaporizes the moisture and becomes latent, thus drying and cooling the material at the same time.

The air within the vacuum container is so rarified as to reduce materially its value as an agent for transferring heat from walls or radiators to the material. The volume of air which must be circulated in a vacuum chamber in order to transfer a given amount of heat is increased several times as compared with air at atmospheric pressures, and the cost of creating a circulation sufficient to transfer any large proportion of the heat required for rapid evaporation is apt to be prohibitive. The evaporated moisture is removed by means of condensers in the vacuum line.

Adiabatic and Constant Temperature Drying

Air dryers are called *adiabatic* when the only source of heat for drying purposes is the heated air entering the dryer from the outside. When part or all of the heat required is supplied by steam coils or other forms of radiation within the dryer itself, it is known as a *constant temperature dryer*. In adiabatic dryers, the temperature of the air decreases, as the drying proceeds, in direct proportion to the amount of heat consumed or made latent by evaporation. Thus the drying rate and the capacity of the air to absorb moisture decline steadily until drying stops entirely or fresh heated air is introduced.

Constant temperature dryers can supply heat by internal recirculation from the radiators to the material and can thus continue the drying operation at maximum speed with little or no change in the air of the dryer, provided that surplus moisture can be disposed of by ventilation or condensation. This advantage is offset, however, in drying some types of material, by the fact that local overheating of the material is liable to occur in some parts of the dryer, due to the transfer of heat from the radiators to the material by direct radiation. In adiabatic dryers, on the other hand, temperatures in different parts of the dryer are usually quite uniform, particularly the wet-bulb temperature, which makes this method especially adapted to the drying of such materials as gelatine which are sensitive to heat when wet and relatively insensitive when dry.

TYPES OF DRYER CONSTRUCTION

Mechanical Contact Dryers

Drum dryers are used for drying thick liquids or pastes. A steam heated cylinder, with its lower side immersed in a bath of the material, is revolved slowly. The film of material that forms on the hot surface of the drum dries rapidly and the resultant solid is scraped off by a fixed knife edge.

Cylinder or can dryers are designed for the continuous removal of moisture from material in the form of thin rolled sheets such as textiles, paper, and pulp products. Heat is transferred to the material by direct contact with a series of steam-heated cylinders. In case the material shrinks on drying, as does paper, the drives must be arranged so that the speed of the drums is gradually less toward the dry end of the series.

Pan or agitator dryers are used for sludges, powders, or material in lump form and consist of a cylindrical metal shell. The material to be dried is placed in the bottom of the shell and is constantly shifted in position by means of agitators, either the shell or the agitators or both being in motion. Hot air or gas is passed over the material and additional heat is usually supplied from a steam-heated jacket around the container or by steam supplied to hollow stirring arms. Continuous agitation of the charge serves not only to expose new surfaces to contact with the air, but also to reduce the average distance from the interior to the surface of the solid and so to speed up the drying where the rate of liquid diffusion to the surface is the controlling factor.

Rotary dryers are suited particularly to the continuous drying of granular, crystalline, or lumpy material which does not tend to ball or stick together. They consist of a revolving cylindrical shell into which the fresh material is fed at one end and from which the dry material is removed at the other end. Lifting plates usually extend from end to end of the inside of the cylinder, parallel to its axis, projecting radially toward the center. Hot air or products of combustion are blown through the shell, either parallel or counter current to the direction of movement of the material. The rotation of the cylinder continually elevates the material and drops or throws it through the current of hot gas or air, the inclination of the shell moving the charge forward at any desired speed. To furnish additional heat to the material by contact, the cylinder is often provided with a steam jacket or with steam coils inside the cylinder. In drying material which is not injured by high temperatures, the outside of the shell may be fired directly and the products of combustion then led through the dryer in contact with the material.

Air Current Dryers

Spray dryers are used for the drying of thick liquids, including any product in solution, suspension or emulsion, such as milk and rubber latex. The liquid is usually first condensed to from 35 to 50 per cent solid content and is then atomized in the form of a fine spray at the top of a lofty chamber, falling through a current of heated air or furnace gases, the dried powder accumulating at the bottom of the chamber. The air can be heated to a considerably higher temperature than would be used for the same material in a contact dryer and the drying is practically instantaneous. The spraying may be done by atomizing nozzles, worked either by the pressure of the liquid or by compressed air, or the liquid may be dropped in a fine stream on to a revolving disc rotating at high speed. That portion of the powder that is carried away with the air currents may be recovered in dust collectors and the air or gas may be recirculated in part, after removing surplus moisture.

Loft, compartment, cabinet or room dryers consist of room-like enclosures or boxes in which the material to be dried is placed on trays, trucks, racks, or moving conveyors and is heated by warm air currents which also serve to carry away the evaporated moisture. Drying of this sort is sometimes called *air-processing*. The air is warmed, either by direct mixture with furnace gases, or by contact with surfaces heated by direct flame, flue gases, steam, hot water, or electricity. The source of heat may be *direct*—located within the dryer, usually in the form of wall coils, floor coils, or distributed coils—or *indirect*, the air being heated by radiators outside the dryer and circulated through the dryer by fans and distributing ducts. Baffles are often used to assure the passage of the heated air directly over the surface of the material and to prevent short-circuiting from inlet to outlet. Where the material is placed on trays, shelves or racks, it is advisable to use open-wire screen bottoms for small material or leave spaces between larger articles when possible, to allow the air to travel not only over the material but also upward or downward through it.

Tunnel dryers consist of a comparatively long, narrow box-like enclosure, through which the solid to be dried is moved either continuously or periodically at short intervals, being fed in at one end in a fresh condition and removed from the other end in a dry condition. The material may be carried on some type of mechanical conveyor or on wheeled cars or trucks moving on a track. The drying is done by means of heated air which moves through the dryer from one end to the other, warming the material and removing the evaporated moisture. Some products dry best if the air and material are made to move in the same direction but in most cases it is found best to have the air move in a direction opposite to the travel of the material, that is, counter-currently. Where wheeled cars are used for heavy, bulky products, the rails in the tunnel are often sloped in a ratio of from 60 to 1 to 100 to 1 to obtain the benefit of gravity in moving the material.

One end of the tunnel is usually hotter than the other, both to suit the varying requirements of the different stages of drying and to take advantage of gravity in moving the air end-wise of the dryer. In the natural-draft tunnel, heat is provided at the hotter end by steam coils or other means and the evaporated moisture is removed at the opposite end by means of ventilating chimneys. In the forced-draft or blower type of tunnel, the air is circulated through the tunnel by fans, being heated either by direct radiation within the tunnel or indirect radiation in the fan duct or a combination of both. Evaporated moisture may be removed either by ventilating chimneys or duct openings or by condensers in the duct system.

MECHANISM OF THE DRYING

Stages of Moisture Diffusion

A thorough knowledge of the mechanism of the diffusion of moisture from the interior of a solid material to the surface and into the air is necessary to an understanding of the different types of commercial dryers and is essential where the design of the dryer is to be based upon small-scale laboratory tests. Assuming uniform velocity and distribution of air at a constant temperature and humidity, over the surface of the solid, the drying cycle will be divided ordinarily into two distinct stages. The first stage, known as the *constant rate period*, is found in the drying of any very wet solid as long as moisture is brought to the surface so rapidly that the surface remains thoroughly wet and evaporation can proceed at a constant rate, precisely as from a free water surface. The second stage, known as the *falling rate period*, is reached when the moisture in the material has been dried down to a point called the critical moisture content, below which the diffusion of moisture from the interior to the surface is no longer adequate to keep the surface thoroughly wetted. From this point on, the rate of drying will decrease until the operation is completed.

Constant Rate Period

During the constant rate period, the surface is kept saturated with water by diffusion from the interior and the operation is called *saturated surface drying*. The rate of drying is limited by the rate of diffusion of water-vapor, through the surface air film surrounding the solid, out into the main body of the air. When the heat necessary for vaporization is supplied only by thermal conduction through the surface air film, the temperature of the solid is the wet-bulb temperature of the air. Heat gained by radiation or conduction from adjoining dry surfaces raises the temperature of the surface above the wet-bulb temperature. The vapor pressure of the water at the surface, therefore, increases and consequently the driving force causing diffusion through the surface air film becomes greater, causing a corresponding increase in the drying rate.

By placing the wet material in sight of hot surfaces during this constant rate period, the rate of drying may be increased several fold without overheating the material itself. Similarly, material placed on hot shelves, as well as material dried in shallow pans or on heated cylinders, will dry faster because of the heat received by conduction from the surfaces with which it is in contact. A controlling factor during this stage is the velocity of the air, affecting as it does the thickness of the surface air film through which the water-vapor must diffuse. The higher the velocity, the faster will the drying proceed, the rate of drying varying approximately as the 0.6 power of the air velocity.

Falling Rate Period

After the critical moisture content of the material has been reached, two distinctly different forms of diffusion and evaporation are encountered. In both cases, the drying rate falls off rapidly with reduction of the moisture content. In the first type, known as *unsaturated surface drying*, the rate of evaporation per unit surface area is substantially constant and nearly independent of the thickness of the sheet or layer of the material. However, where the solid gains its heat only from the air around it and obtains none by radiation or conduction from adjacent surfaces, the transfer of heat from the air to the solid is, under constant drying conditions, found to be independent of the moisture content and of any variation in the drying rate due thereto. Furthermore, the drying rate is increased by greater air velocity and by lessened humidity of the drying air. These facts are explained by assuming that evaporation takes place on the surface of the solid, but that the concentration of moisture there is insufficient to saturate the whole surface, so that the surface behaves as though only a part of it were wet.

In the second type of diffusion, known as *sub-surface drying*, the rate of evaporation per unit surface area of the sheet of material is inversely proportional to the thickness and is uninfluenced either by the velocity or the humidity of the surrounding air. The heat-transfer from the air to the stock falls off rapidly as the moisture content and the drying rate decrease. This indicates that evaporation is taking place, not at the surface of the solid, but beneath the surface, so that water as vapor must diffuse not only through the gas film around the solid, but also through that layer of the solid itself between the zone of evaporation and the surface. Consequently, this type of evaporation is known as sub-surface drying, the limiting factor in the rate of drying being the speed of diffusion of the liquid water from the interior of the solid to the zone of evaporation.

The Drying Cycle

In the drying of a typical wet solid under constant conditions, saturated surface evaporation usually starts at a constant rate. This will continue until the critical moisture content of the stock is reached, after which there will follow a period of unsaturated surface drying, at a falling rate. This is finally superseded by sub-surface drying which continues at a decreasing rate until the operation is completed. The drying of a slab of whiting gives a typical illustration of this cycle, as shown in Fig. 1.

Omissions in the Cycle

Many solids such as lumber are so dry at the beginning of the drying operation that the constant rate period of free surface evaporation does not occur. Frequently the surface of the material is dry enough that no surface drying can take place, in which case only the final stage of sub-surface drying is involved. In other instances, the critical moisture content of a wet solid is sufficiently low that sub-surface drying starts almost immediately after the conclusion of the constant rate period. Thus the intermediate stage of saturated surface drying does not occur and the drying is of the sub-surface type during practically the whole of the falling rate period. With other kinds of material, particularly thin sheets such as newsprint paper, sub-surface drying may occur at such a low moisture content that it is not encountered in commercial work, the falling rate period being confined solely in practice, to unsaturated surface drying.

Capillary and Hygroscopic Moisture

Most solid materials to be dried are of a powdery, granular, cellular, or fibrous nature and contain water in two characteristic forms which have a direct relation to the rate and character of the drying operation. The first form is known as *free* or capillary moisture and comprises the water which is contained in the capillary spaces between the particles or fibers of the material. The second form is called *adsorbed* or hygroscopic moisture and is intimately associated with the physical nature of the material, having a direct effect upon such physical properties as size, strength, electrical conduction, heat conduction, etc. Removal of the capillary water has little or no effect upon the material except to reduce its weight, while removal of the hygroscopic water causes definite changes in physical properties and characteristics.

Fiber Saturation Point

The total amount of adsorbed or hygroscopic moisture that a given amount of material can contain is definitely limited. This limit is known as the *fiber saturation point*[1] and corresponds roughly to the critical moisture content. Beyond this point, any additional moisture must be in free or capillary form and the amount of such free water that the material can hold will depend upon the relative volume of capillary spaces that may be present. The fiber saturation point is of particular importance in the drying of thick, bulky materials having a more or less colloidal structure such as lumber and clay products, in which the removal of hygroscopic moisture is accompanied by shrinkage, stiffening, hardening, loss of plasticity, and other physical changes. Successful drying requires that these changes be controlled within safe limits in order to avoid injury to the material.

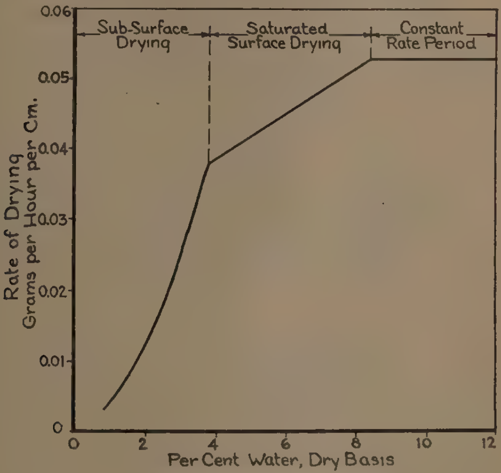


FIG. 1. RATE OF DRYING OF WHITING SLAB

Removal of Free Water

In most commercial products which require a drying operation, the free water contained will flow readily from the interior to the surface by capillary action, as in a wick. Textiles, paper, fiber board, clay products, and the sapwood of most species of lumber represent material of this type, as well as finely-divided materials which come in granular or powder form. In such substances the free water is removed usually without difficulty in the successive stages of saturated surface drying and unsaturated surface drying, followed by the removal of the hygroscopic moisture in the form of sub-surface drying.

---

[1] U. S. Forest Service Bul. 70, p. 82, *Effect of Moisture on Strength*, Tiemann, 1907.

In certain other materials of thick and more or less rigid form, notably the heartwood of some kinds of lumber, the free water contained in the capillary spaces appears to be, in a sense, *bottled up* and cannot be made to flow from the interior to the surface in appreciable amounts. To remove the free water from such substances necessitates sub-surface vaporization within the material at the boundary of the free water zone, followed by diffusion of the vapor through the surrounding zones either as vapor or as adsorbed hygroscopic moisture. In either case, the zone surrounding the free water must be dried below its fiber saturation point in order to lower the vapor pressure to a point below saturation and thus permit this diffusion to take place. This means that shrinkage and other physical changes such as stiffening or hardening must occur in this outer zone before the interior portions have lost their free water and are ready for such changes. Consequently severe and harmful tensile and compressive stresses are apt to be set up in the drying of this type of material, due to unequal and non-synchronous shrinkage in the different zones, resulting in such injuries as surface cracking, honey-combing, warping, and *case-hardening*, or the setting of the surface portion in a stiffened expanded condition.

In obtaining maximum speed of drying of materials in which there is no capillary flow of free water to the surface, an increased moisture movement may be produced by passing an electric current through the material or by applying heat by contact directly to the interior or to one or both sides. Such means are usually impracticable, however, and dependence must be placed in most cases upon the effect produced by heated air or other gas surrounding the material. In such cases the speed of drying can be increased in only two ways, first by lowering the moisture content at the surface through the use of a lower humidity, or second, by increasing the temperature. The risk of harmful shrinkage limits the first, and the risk of exceeding the critical temperature of the material limits the second.

The use of too high a temperature in removing the free water from fibrous or cellular materials of this kind, increases the plasticity of the structure and at the same time is apt to create a liquid tension within the cells themselves. This force, which may amount to many atmospheres under certain conditions, tends to draw the walls of the cells together, thus producing a *collapse* of these cells. This phenomenon is the cause of much injury in the drying of certain kinds of lumber and is probably present to a greater or less extent in the drying of all refractory material of a cellular nature through which the free water cannot flow by capillarity.

Another result of trying to force the drying of these refractory materials at too fast a rate is the increasing resistance to the passage of heat from the surface to the interior and the passage of vapor outward, as the dryness of the surface increases. With many materials of this type, if the surface is allowed to dry below a certain point, it becomes increasingly difficult, not only for additional heat to penetrate to the interior, but also for vapor to work its way outward through the dry outer zones to the surface. Under these conditions the drying becomes very slow or ceases entirely and is replaced by a baking operation.

Internal Moisture Gradient

In drying by surface evaporation, an internal concentration gradient is set up between the moisture content at the center of the material and the moisture content close to the surface. The steepness of this gradient is dependent upon the rate of evaporation at the surface and the rate of transfusion of moisture from the center outward. In general, the steeper the gradient, the faster the drying. Since raising the temperature increases the rate of transfusion, the rate of drying is thereby increased without increasing the steepness of the gradient. For this reason the maximum temperatures which can be used without injury to the material will usually be found to produce the maximum rate of speed consistent with safety.

In keeping the moisture gradient within safe limits, during those stages of drying when surface shrinkage is taking place, the drying should be retarded by preventing the surface from drying below a certain critical moisture content which must be determined experimentally for different materials. This control of surface drying is accomplished by regulation of the relative humidity of the air in the dryer in conjunction with the regulation of the temperature. In continuous dryers of the counter-current type, the fresh material is subjected to the lowest temperature and highest humidity while the dried product at the discharge end meets the hottest and dryest conditions, thus furnishing a degree of automatic regulation to suit the needs of the stock. A higher humidity can also be provided by recirculating a portion of the air in the dryer and by means of steam jets.

Equilibrium Moisture Content

With every material having hygroscopic properties, a point of equilibrium is reached between the vapor pressure of the moisture in the air and the vapor pressure of the moisture in the surface of the material. Every combination of temperature and humidity produces a corresponding equilibrium moisture content in the material. It is, therefore, possible to so regulate the conditions in the dryer at any stage of the operation that moisture in the material cannot drop below a certain equilibrium point, as may be desired for best results.

In the drying of most hygroscopic materials, the drying is continued until a somewhat lower moisture content is reached than equilibrium under conditions in use, to allow for enough regain to balance the moisture remaining in the interior and surface to a uniform condition. It is usually undesirable to carry the drying much beyond the equilibrium point of the material in use, as over-drying is liable to produce undesirable physical changes in the material, and such over-drying also unnecessarily prolongs the time and increases the cost of the operation.

CONTROL OF THE DRYING OPERATION

Circulation Control

Circulating air or gas currents must have a sufficient velocity over the surface of the material being dried to transfer the heat required for evaporation, with the exception of that provided by conduction and radiation and at the same time to carry away the water evaporated. The volume needed for moisture removal will correspond roughly with the volume needed for heat transfer. A third requirement is that the velocity should be sufficient to carry away the film or layer of nearly saturated air that is apt to remain in close contact with the evaporating surface and whose high vapor pressure retard further evaporation. During the saturated surface drying stage, the drying rate will vary directly with the velocity of circulation over the material. When the stage of subsurface drying is reached the velocity of circulation becomes of less importance, since the drying cannot proceed any faster than the moisture vapor can transfuse from the interior to the surface.

Circulation is expressed either by the rate of air flow over the material per minute, or by the number of air changes in the dryer per minute or per hour. The former is the logical method as it expresses positive drying power while the latter may be misleading because of possible short-circuiting of some of the circulating medium without coming in contact with the material.

Circulation by gravity, due to the rising tendency of heated air and the falling tendency of cooled air, is the only means of circulation in many of the older and simpler forms of dryers. In the more modern forms of high-speed dryers, mechanical circulation is produced either by blowers of the centrifugal type outside of the dryer, or by multiple fans of the propeller type inside the dryer, or by a combination of both. In addition, a certain amount of internal gravity circulation is sometimes provided in mechanical draft kilns where direct radiators are located within the dryer.

In some mechanical systems the general volume movement is taken care of by an external blower and the required high velocity over the surface of material is obtained from internal fans, placed to furnish a transverse and more or less local recirculation. A good example of this type of dryer is a tunnel dryer for light leather. The skins are hung on sticks which are carried through the dryer on a conveyor, the plane of the skins being at right angles to the axis of the dryer. In order to provide the velocity of 5 ft. per second over the surface of the skins necessary to complete the drying in a minimum time, a series of propeller fans, equipped with long blades, few in number, and rotating at slow speeds, are placed above the skins from end to end of the dryer blowing downward. (See Fig. 2).

Mechanical systems are best suited to rapid drying under close control and may be designed with automatic control instruments which will hold the temperature within 2 deg. fahr. and the humidity within a 4 per cent relative humidity. Indirect heaters of high efficiency are usually placed in the blower ducts and the humidity is controlled either by steam jets, air washers, refrigerating coils, or cold water coils, supplemented by ventilation. In addition, provision is often made to recirculate part of the outgoing moist air coming from the dryer in case a high humidity is desirable. In such dryers a higher thermal efficiency may be obtained by the use of interchangers, by which the saturated air coming from the washers is partially heated by absorption of heat through contact with the ducts containing warm, moist air, returning from the dryer.

Natural draught circulation has the advantage of simplicity and low cost of installation and operation and can be utilized to very good advantage for many kinds of drying. Such dryers are usually of the ventilated type in which a minor part of the moisture-laden air in the dryer is discharged by means of ventilating flues or chimneys and is replaced by fresh air coming in through special flues or through cracks and openings around the doors. In some types, cold water coils or sprays are used to create a positive movement of air within the dryer. Convection currents, circulating from the radiators to the material and back again, provide the principal volume of circulation in dryers of the gravity type. Best results in securing a uniform circulation throughout the dryer are usually obtained by placing the radiators beneath the material at intervals, with baffles of various types arranged in such a way as to guide the air currents over and through the material.

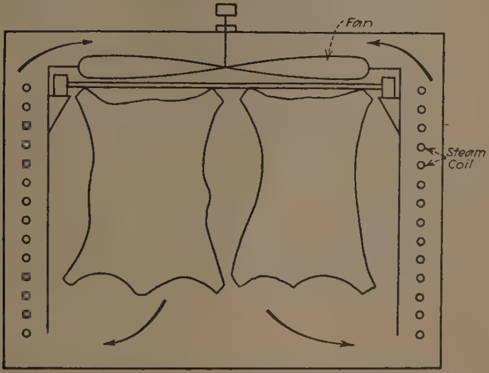


FIG. 2. SECTION THROUGH A TYPICAL LEATHER DRYER

Heat and Humidity Control

Steam is used as a source of heat and humidity in most modern dryers and lends itself readily to automatic control by means of thermostatically operated valves. Direct fired dryers are less easily controlled but are used for products which do not ordinarily require close control. For many types of dryers, hand operation of valves and the maintenance of a uniform steam pressure in the mains will give sufficiently close control, if checked by the periodic reading of temperatures within the dryer. In other cases such crude control would result in serious losses of material.

In some operations, time controllers are used which automatically alter the conditions according to a predetermined schedule and finally bring the drying operation to a close. With other dryers regulation is obtained in accordance with the loss in weight of samples of the material suspended on sensitized scales within the dryer, the drying being automatically terminated when the samples reach the desired degree of dryness. Generally, however, the only function of the control instruments is to maintain the desired temperature or humidity and any change in the conditions must be made by the operator by re-setting the instruments.

The higher the temperature, other things being equal, the faster will the moisture in the material transfuse to the surface and the faster will the drying proceed. Hot water passes through the material more rapidly than cold water because of its increased vapor pressure as well as its decreased viscosity. Increasing the rate of surface evaporation by greater circulation at low temperatures produces faster drying only when a corresponding increase in the rate of transfusion is obtained.

Provision must be made in every dryer to dispose of evaporated moisture as it comes from the material. In most dryers this is done by discharging part or all of the moisture laden air to the atmosphere, replacing it with an equal amount of outside air. In some types, particularly of the blower style, the surplus moisture is often removed by some form of condenser such as cold water coils or sprays. It is a mistake to attempt to obtain a practically saturated condition of the leaving air, as this is apt to slow down the speed of drying and cause an undesirable amount of condensation in the moist air ventilators or ducts returning to the blower. A saturation of from 50 to 75 per cent in the leaving air is usually as high as can be obtained without sacrificing speed.

Operating the Dryer

No matter how well the dryer may be designed, a considerable part of the success of a drying operation depends upon the operator. He must watch the material and study the results in a constant effort toward improvement. Good dryer operation includes regular sampling and testing of material, watching the conditions within the dryer, and keeping systematic and complete records of all essential data such as the movement of material, the length of the drying period, the temperatures and humidities at critical points in the dryer, and the extent to which the equipment is kept fully occupied. Standard schedules of drying time and drying conditions for material of different kinds are also useful in estimating production and regulating the operation of the dryer.

Moisture Content Calculations

Moisture content is usually expressed as a percentage of the original combined weight of the material and its contained water. Thus, if the moisture content were 20 per cent, the dry material would weigh 80 per cent of the total weight. In drying some types of material, notably lumber, it is customary to use the *bone-dry* or water-free weight of the material as the divisor, the weight of the water being calculated as a percentage of this dry weight. Regain, or absorption of hygroscopic moisture after drying, is almost always expressed by the latter method, as a percentage of the water-free weight of the material.

TABLE 1. DRYING TIME AND CONDITIONS FOR REPRESENTATIVE MATERIALS

KIND AND THICKNESS OF MATERIAL	TEMPERATURE DEG. FAHR.	DRYING TIME
Bedding	150–190	
Cereals	110–150	
Cocoanut	145–155	4–6 Hours
Coffee	160–180	24 "
Cores, Oil Sand, for molding ½ in. – 1 in. thick	300	30 Minutes
Black sand with Goulac Binder about 6/10 of time for oil sand cores 3 in. "	480	2½ Hours
8 in. "	480	4½ "
16 in. "	700	10 "
Feathers	150–180	
Films, Photographic	90	
Fruits and Vegetables	140	2–6 "
Furs	110	
Glue	70–90	2–4 "
Glue Size on Furniture	130	4 "
Gut	150	
Gypsum Wall Board Start Wet	350	60 Minutes
Finish	190	
Gypsum Blocks	350–190	8–16 Hours
Hair Goods	150–190	1 Hour
Hats, Felt	140–180	
Hops	120–180	
Hides, Thin leather	90	2–4 Hours
Ink, Printing	70–300	
Knitted Fabrics	140–180	
Leather, Thick Sole	90	4–6 "
Lumber, Green Hardwood	100–180	3–180 Days
Lumber, Green Softwood	160–220	2–14 "
Macaroni	90–110	
Matches	140–180	
Milk and other Liquid Foods (Spray Dried)	250–300	Instantaneous
Molds, Green Sand, C. I. Flasks (one Surface only exposed)		
8 in. thick	600	6 Hours
13 in. "	700	13 "
Nuts	75–140	24 "
Paper, Glued	130–300	
Paper, Treated	140–200	
Rubber	80–90	6–12 "
Sand, loose, 1 in. deep	300	10–15 Minutes
Shade Cloth	240	1–2 Hours
Soap	125	12 "
Starch	180–200	1–4 "
Stock Feed, Mixed	180–220	20–30 Minutes
Sugar	150–200	20–30 "
Tannin and other chemicals (Spray Dried)	250–300	Instantaneous
Terra Cotta (air-drying in conditioning room)	150–220	12–96 Hours
Wall Board	200–250	12–24 "

The usual procedure, in determining the moisture content of a representative sample of the material, is to weigh this sample before it has had a chance to lose weight by evaporation, then dry it to a water-free basis in an oven heated to a temperature slightly above the boiling point (about 215 deg. fahr.) until it has reached constant weight, then take a second weight record, and subtract the second weight from the first to determine the weight of the water. This figure can then be multiplied by 100 and divided by either the first weight or the second weight to obtain the percentage based on the original or final weight of the sample. Ovens used for this purpose are usually heated by steam or electricity and thermostatically controlled to prevent overheating.

Time of Drying

In Table 1, the average temperature range and drying time for a number of representative materials are given. The figures do not represent the maximum speeds attainable nor necessarily the optimum temperature conditions but are fairly typical of general commercial practice. In materials in which no capillary movement of free water can take place, the speed is limited by the rate of transfusion through the material which is again determined by the critical temperatures and maximum gradients which can be used without injuring the material. In this case, theoretical analysis according to Lewis shows that in the early stages the time of drying is proportional to the square of the thickness and to the square of the total moisture lost, and the time-moisture curve is a parabola. In the later stages, after all free water has been evaporated, the curve becomes logarithmic. The form of this drying curve will, in general, resemble that shown in Fig. 3. On the other hand, in drying materials in which free water can flow by capillary action at a sufficient rate to keep pace with surface evaporation, the time is proportional to the first power of the thickness and the rate will be governed by the drying conditions of the air and the area of surface exposed.

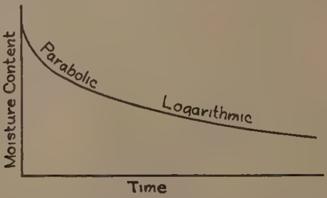


FIG. 3. TYPICAL TIME-MOISTURE CURVE FOR MATERIALS IN WHICH NO CAPILLARY FLOW OF FREE MOISTURE OCCURS

DRYER DESIGN

Methods of Calculations

A psychrometric chart applying to atmospheric pressure and plotted in units convenient for use in dryer calculations, is given in Fig. 4. The amount of moisture in the air, H, is given in pounds of water per pound of dry air. With this choice of units, changes in H represent directly the

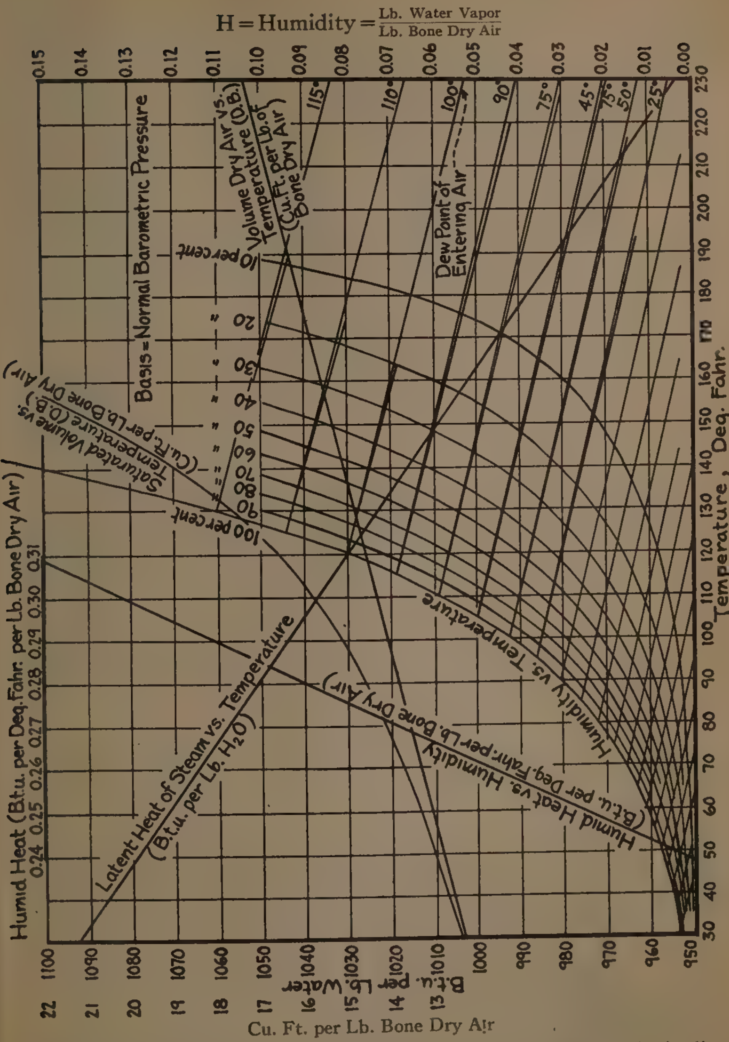


FIG. 4. PSYCHROMETRIC CHART PLOTTED IN UNITS CONVENIENT FOR USE IN DRYER CALCULATIONS

moisture picked up by the air from the material being dried. The inclined straight lines are adiabatic cooling lines for air in contact with water at its wet-bulb temperature, and also represent the cooling of air in the adiabatic drying of any stock, the sensible heat of which is negligible in comparison with the heat of vaporization of the water in it.

The following nomenclature and explanation of terms will be used in the discussion of drying calculations:

H = humidity of air, pounds of water-vapor per pound of dry air.
G = pounds of dry air supplied to the dryer per unit of time.
S = pounds of stock dried per unit of time in a continuous dryer.
S' = pounds of stock changed per batch to a discontinuous dryer.
Θ = time.
Q = total heat supplied to the dryer.
t = air temperature.
t' = stock temperature.
t'' = average stock temperature over short-time interval, in a batch dryer.
t_w = wet-bulb temperature.
s' = specific heat of the stock.
B = total radiation and conduction losses per unit time.
w = pounds of water per pound of dry stock.
r = heat of evaporation of water.
s = humid heat of air, *i.e.*, heat necessary to raise 1 lb. of dry air + H lb. of steam 1 deg.

Subscript 1 designates conditions at the point where the material in question (air or stock) enters and 2 where it leaves the dryer.

Air dryers may be divided into two classes, those in which *all moisture* evaporated from the stock *leaves the dryer as vapor* in the effluent air, and those in which *part or all* of the moisture *is condensed* from the air *in the drying equipment itself*. In any continuously operating dryer of the first type the relation between moisture content of the stock and quantity of air required for the drying operation is given by the equation:

$$G\,(H_2 - H_1) = S\,(w_1 - w_2) \tag{1}$$

In discontinuous dryers, *e.g.*, compartment dryers, the drying operation is given by the equation:

$$G\,(H_2 - H_1) = S'\,\frac{dw}{d\Theta} \tag{1a}$$

In the continuous dryer, the heat consumption per unit time is:

$$\frac{Q}{\Theta} = Gs_1\,(t_2 - t_1) + G\,(r_2 + t_2 - t'_2)\,(H_2 - H_1) + S\,(t'_2 - t'_1)\,(s' + w_1) + B \tag{2}$$

Equation (2) assumes continuity of operation. For charge or batch operations, the total time of the drying cycle may be broken up into a number of periods, sufficiently short so that over each period average values of t, t' and H may be employed provided the third term of the right-hand member of the equation is modified to read:

$$S'\,(t''_2 - t''_2)\,(s' + w_1),$$

and in the second term t'_2 be replaced by

$$\frac{t'_1 + t''_2}{2}$$

Theoretically these periods should be very short and the equation integrated. Practically the error introduced by using a small number of long periods and employing average values of the variables over each rarely introduces serious error. The evaluation of equation (1_a) may be approximated in a similar manner.

The first term of the right-hand member of equation (2) represents heat lost as sensible heat in the effluent air. In many drying operations this becomes excessive. Each pound of air supplied should remove the maximum amount of moisture. This is best accomplished by bringing the air into contact with the stock with sufficient intimacy so that the air leaving the dryer is saturated or nearly so. Counter-current as against parallel flow of air and stock gives rise to optimum operating conditions, resulting in a minimum quantity of air required, (G), and a corresponding minimum loss, as sensible heat, in the exit air. Similarly, continuous operation is superior to intermittent operation.

Despite the fact that the sensible heat loss increases with the rise in temperature of the air, the percentage of heat lost from this source decreases, provided the increase in moisture-carrying capacity of the air due to high temperature is actually utilized. To secure maximum thermal efficiency in drying a high outlet air temperature and saturation is imperative.

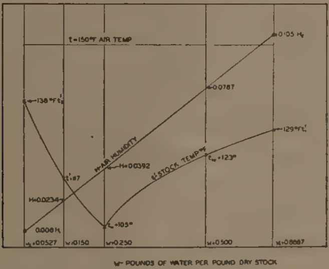


FIG. 5. CHART SHOWING TEMPERATURE-HUMIDITY RELATIONSHIPS IN A DRYER

The Ventilation Phase

The technique of attack of the *ventilation phase* of a drying problem is best made clear by an illustration. Assume that a material containing 40 per cent moisture is to be dried until this quantity of moisture is reduced to 5 per cent by weight. The material will stand an air temperature of 150 deg. fahr. and it is possible to provide sufficiently good contact between the material and the drying air that the effluent air can be brought up to 50 per cent humidity at 150 deg. The dryer is to use room air, the humidity and temperature of which may be assumed to average 70 deg. fahr. and 50 per cent. A counter-current dryer will be employed and the air in this dryer will be kept at a substantially constant temperature of 150 deg. fahr. by heaters thermostatically controlled. The stock enters at 70 deg. fahr., rises quickly to the wet-bulb temperature of the air with which it is in contact and is found experimentally to maintain wet-bulb conditions until the moisture content has fallen to

20 per cent. From this point its temperature rises progressively as it dries. In this range the difference in temperature between stock and air, divided by the wet-bulb depression, may be assumed proportional to the moisture content.

The moisture content of the entering stock, in the units here employed, is:

$$w_1 = \frac{40 \text{ per cent water}}{60 \text{ per cent dry stock}} = 0.6667;\ w_2 = \frac{5 \text{ per cent water}}{95 \text{ per cent dry stock}} = 0.0527.$$

$w_1 - w_2 = \Delta\ w = 0.614$ lb. water evaporated per pound of dry stock. Since the air leaving the dryer is 50 per cent saturated at 150 deg. from Fig. 4, $H_2 = 0.105$. Similarly, $H_1 = 0.008$, corresponding to 50 per cent humidity at 70 deg. fahr. Consequently $H_2 - H_1 = \Delta\ H = 0.097$ lb. water evaporated per pound dry air.

Inspection of equation (1) shows that (H) is linear in w. Hence, one can construct Fig. 5, the line marked (H) being drawn connecting the initial and final points just computed.

Since the air leaving the dryer has a temperature of 150 deg. and a humidity of 0.105, Fig. 4 shows that its wet-bulb temperature is 129 deg. fahr. This is plotted at the right-hand side of Fig. 5. Since the stock maintains a wet-bulb temperature down to 20 per cent moisture, where $w = 0.25$, the corresponding humidity can be computed by the use of equation (1) or by reading directly from the diagram, the value being 0.0392. Fig. 4 shows that the corresponding wet-bulb temperature is 105 deg. Any intermediate point on the wet-bulb temperature curve can be calculated similarly. The points for $w = 0.5$ are shown on Fig. 5.

Below the point, $w = 0.25$, the temperature of the stock begins to rise appreciably above the wet-bulb temperature. Its temperature at any given point in this range, for example at $w = 0.15$, may be computed as follows: At this point, $H = 0.0234$ [from equation (1)] and from Fig. 4, $t_w = 95$ deg. Hence the wet-bulb depression, $t - t_w = 150 - 95 = 55$ deg. The assumption made regarding the relation between stock temperature and moisture content in this range may be formulated:

$$\frac{\Delta\ t'}{t - t_w} = \frac{w}{0.25}$$

At the point $w = 0.15$, $\Delta\ t' = 33$ deg., $t' = 117$ deg. The temperature of the stock leaving the dryer, similarly computed, is 136 deg.

Fig 5 thus computed gives in graphical form the information as to the temperature humidity relationships in the dryer. The air requirements can be computed by equation (1). Thus, per 100 lb. of dry stock it is necessary to supply 633 lb. of dry air. Furthermore, since from Fig. 4 it is seen that the volume of 50 per cent saturated air at 70 deg. fahr. is 13.55 cu. ft. per pound, 8,580 cu. ft. of room air must be supplied per 100 lb. of dry stock. Similarly, since the volume of 50 per cent saturated air at 150 deg. is 18.0 cu. ft. per pound, the volume of hot-wet air discharged from the dryer is 11,400 cu. ft. per 100 lb. of dry stock. Finally, the heat necessary to supply to the dryer as a whole or to any section of it may be computed from equation (2).

Rule of Thumb Estimating

Where time does not permit detailed calculations, a method sometimes used in dryer design is to estimate a consumption of about 2½ lb. of steam furnished to the dryer for each pound of water evaporated from the material, although under favorable conditions 2 lb. of steam is sufficient. In the very slow drying of thick, bulky materials such as hardwood lumber, at low temperatures, as much as 15 lb. of low-pressure steam is sometimes required per pound of water evaporated.

The temperature will drop approximately 8½ deg. fahr. per grain of water evaporated per cubic foot of air (measured at 70 deg. fahr.) or approximately 0.62 deg. fahr. per pound of air at any temperature. Approximate calculations may be based on air volume but for exact determinations the weight of the air should be used, since the weight is a fixed quantity at any temperature, but the volume will vary with the amount of moisture absorbed and the temperature.

DRYER ARRANGEMENT AND CONSTRUCTION

Outside handling and storage space usually is an important consideration in dryer design. Continuous dryers have an advantage in this respect since they provide storage for a considerable proportion of the material in process, while for charge dryers enough outside space must be provided to handle at least one full charge awaiting the dryer and one full charge upon removal. The more rapid the drying operation, the more efficient must be the handling facilities, in order to hold operating costs to a minimum and to keep the dryer operating at maximum capacity.

An important consideration in construction is to provide tight, well-insulated doors which can easily be opened and closed, with minimum labor and loss of time. Fire resistance of doors is also important, in case of outside exposure to fire risks. Insurance rates must be considered in their relation to fire protective arrangements such as automatic sprinklers, fire doors and walls, steam jets for use in smothering fires that may start inside the dryer, etc. Ceilings of dryers should be as flat as possible and the space between the material and the walls and ceiling should be held to a minimum. A factor often overlooked is that of suitable provision for ventilation of the space around the dryer openings so that warm moist air which may escape from the dryer when the doors are opened may be carried away before it has a chance to condense on the ceiling or windows of the building in which the dryer is located or into which it opens. Convenient arrangements for the operator should also be provided where tests can be made, records kept, and clothes changed, in case it is necessary for the operator to work inside the dryer.

EXPERIMENTAL TECHNIQUE

One vitally important phase of dryer design has been ignored in the preceding discussion, namely, *the time required to dry the stock*, or, what is equivalent to the same thing, *the size of the dryer*, and the character and extent of the *contact surface* between the stock and the air. In general, this cannot be determined except on the basis of experimental data on the specific material to be dried. The source of such data may either be the known performance of actual commercial drying installations handling the same stock or direct experimental determinations in the laboratory. Data of this type for many materials are given in Table 1.

Where it is necessary to determine drying conditions and rate in the laboratory, it is vitally important properly to control the experimental conditions. Where possible, the material upon which the experiments are made should have the same shape and size as that to be treated commercially. Furthermore, the conditions of exposure to the drying air, the temperature and humidity of that air, and its velocity and distribution over the material should be identical with those used in the full-scale operation. Where the commercial operation is by batch, it is relatively easy to duplicate commercial conditions in the laboratory. However, where continuous operation is intended, it is usually difficult to build a continuous experimental dryer. In such a case, a preliminary diagram of the type of Fig. 5 should be constructed and the drying conditions of the batch experimental operation controlled in the laboratory to conform to the humidity moisture content relationship of the ultimate continuous operation. In this way, dependable data on the drying rate can be obtained in the laboratory.

An understanding of the mechanisms of drying and of the drying characteristics of the material to be dried is of the utmost importance in designing successful and economical dryers, especially in the interpretation and extrapolation of plant and laboratory test data. Air velocity has an important influence on the rate of drying in the constant rate period and in the first zone of the falling rate period, but in the second zone of the falling rate period the rate of diffusion of water to the surface controls the drying, and hence increasing the air velocity past the surface can have little effect on the rate of drying.

REFERENCES

Commercial Drying Apparatus, By L. P. Dwyer (Transactions, A. S. H. V. E., Vol. 22, 1916, No. 418).

Artificial Drying with Special Reference to the Use of Gas, By G. C. Shadwell (Transactions, A.S.H.V.E., Vol. 23, 1917, No. 440).

Drying by Evaporation, By F. R. Still (Transactions, A. S. H. V. E., Vol. 23, 1917, No. 441).

Drying in Industrial Plants, By J. G. Ross.

High Temperature Drying, By Burt S. Harrison (Transactions, A. S. H. V. E., Vol. 24, 1918, No. 472).

The Temperature of Evaporation, By W. H. Carrier (Transactions, A.S.H.V.E., Vol. 24, 1918, No. 473).

Commercial Dehydration, By J. E. Whitley (Transactions, A. S. H. V. E., Vol. 26, 1920, No. 578).

Drying as an Air Conditioning Problem, By A. W. Lissauer (Transactions, A. S. H. V. E., Vol. 27, 1921, No. 600).

A Chronological Survey of Drying and Dryers, By J. E. Bolling (Journal, A. S. H. V. E., October, 1921, p. 715).

Modern Drying Machinery, By H. B. Crenshaw, London, 1926.

The Kiln Drying of Lumber, By A. Koehler and R. Thelen, New York, 1926.

Drying, By W. H. Carrier (Marks' Mechanical Engineers Handbook, 2d ed., 1924).

Drying, Kent's Mechanical Engineers Handbook, 10th ed., 1923.

Calculations for Drying Design, By Grosvenor (*Transactions, A. I. Chem. Eng.*, 1908, p. 184).

The Rate of Drying Solid Materials, By J. Lewis (*Ind. Eng. Chem.*, 1921, p. 427).

Principles of Chemical Engineering, By Walker, Lewis, McAdams, 1923. (Chapters 12 to 16 on Evaporation, Humidity and Drying.

The Kiln Drying of Lumber, By H. D. Tiemann (Lippincott, 1920).

Drying by Means of Air and Steam, By E. Hausbrand (D. Van Nostrand & Co., 1901).

Principles of Drying Lumber and Humidity Diagram, By H. D. Tiemann (Forest Service Bul. 104, 1912).

Symposium on Drying. Articles by W. K. Lewis, W. H. Carrier, A. E. Stacey and Fleming, R. G. Merz, G. B. Ridley, C. O. Lavett, D. J. Van Marle (*Jour. Ind. Eng. Chem.*)

CHAPTER 30

OZONE AND VENTILATION

Physical, Chemical and Germicidal Properties; Deodorizing Ozone Production; Proper Concentration; Industrial Uses.

OZONE is a normal constituent of pure, natural air and its quantity varies with the topography of the country, particularly with regard to the altitude, the presence of bodies of water, and certain plant life. It is used in ventilating systems to destroy odors.

Ozone is produced, photo-chemically, by ultra-violet light of short-wave length (1,200–1,800Å), while light of greater amplitude (3,000–3,300Å) exerts a decomposing effect. At high altitudes, where short-wave radiations are more intense, ozone naturally occurs in greater quantities. It is continuously under the destructive effect of longer waves, however, but a dynamic equilibrium is finally reached between the rate of formation and the rate of decay, which shifts with the altitude. Since light of longer wave length penetrates closer to the earth than does that of shorter amplitude, the equilibrium becomes favorable to ozone directly as the altitude.

In summing up the evidence at hand it may be concluded that ozone, while mostly absent from city air, is normally present in pure country air, but in amounts that are difficult to estimate accurately. In nature the air is continuously under ionizing influences, and the enclosing of air, as in buildings, excludes these influences, in addition to destroying the original ionization of the air. Ionization is involved in chemical activity.

The process of ozonizing, in addition to supplying ozone, ordinarily absent from city air, further provides considerable ionized oxygen, producing a fresh, chemically active air, comparable with fresh, pure air of nature.

PHYSICAL CHARACTERISTICS[1]

Density: Calculated Value; 1.66.

The foregoing value refers to air as unity. Its rate of diffusion, with respect to oxygen is 0.75.

At a temperature of 270 deg. cent. (518 deg. fahr.), ozone is instantly decomposed.

Odor: Strong, penetrating and characteristic. Perceptible to the sense of smell in concentrations above 0.01 p.p.m., by volume.

Olfacity (minimum perceptible concentration expressed in molecules per c.c.) 2.705×10^9 at 0 deg. cent. and 760 m.m. Hg.

Solubility: Soluble in water and dilute acids, quite soluble in carbon tetrachloride and many vegetable oils.

---

[1] See THE GUIDE, 1929, for further physical properties.

Its solubility in water, like all gases, is dependent upon the temperature and partial pressure. Nernst (Festschrift, 391; 1912) gives the solubility coefficient for water at 0 deg. cent. and 760 m.m. Hg., as 0.494; or about ten times as great as oxygen. However, high concentrations of ozone, in solution, in water, are not easily obtained in practice, due to the low concentrations at which ozone is available commercially. Of the two factors, temperature appears to have the greatest bearing.

CHEMICAL REACTIONS INVOLVING OZONE

Ozone is one of the strongest oxidizing agents known. It is capable of oxidizing all of the elements, with the exception of gold and some of the metals of the platinum group.

In the dry state its activity towards metals is not so marked, and in very low concentrations, such as used in ventilation, it may be considered as being practically inert towards the common metals.

It exerts a depolymerising action on the rubber molecule, its destructive effect being quite characteristic even at comparatively low concentrations (ca. 3 to 4 ppm). However, unless the rubber is under stress, fairly high concentrations (ca. 50 to 100 ppm), fail to effect it appreciably. The low concentrations used in ventilation have no noticeable effect on ordinary rubber goods.

Iodine is liberated from potassium iodide by ozone. Many of the low oxidation salts (ous salts) are carried to a higher degree of oxidation (ic salts) by ozone.

Generally, ozone reacts to liberate molecular oxygen, only the third atom entering into combination. This may be expressed by the equation:

$$M + O_3 = MO + O_2 \qquad (1)$$

which is typical of the inorganic reactions of ozone. In many cases, however, ozone reacts as follows:

$$M + O_3 = MO_3 \qquad (2)$$

This reaction is exemplified in the oxidation of sulphur dioxide:

$$3SO_2 + O_3 = 3SO_3$$

Reaction (2) is more typical of the organic, than the inorganic, reactions of ozone, as illustrated by the oxidation of urea:

$$CO(NH_2)_2 + O_3 = N_2 + CO_2 + 2H_2O \qquad (3)$$

In the oxidation of odoriferous substances, commonly met with in ventilation, such as skatole, indole, amine compounds, and the like, reaction (3) may be said to hold throughout. Where an amino group is present, molecular nitrogen will be produced, in addition to the carbon dioxide and water produced from hydrocarbons.

EFFECT OF OZONE ON MICRO-ORGANISMS

Ozone compared with other gaseous germicides, generally used for fumigation, rightfully holds first place, as is revealed by the following table:

Agent	Per cent necessary in moisted air to be germicidal
Ozone	0.1
Formaldehyde	1.0
Sulphur Dioxide	4.5

One-tenth per cent by weight, of ozone in air is equivalent to approximately 560 parts per million. Such a concentration of ozone could never be used in ventilating work. Rideal (Ozone, D. Van Nostrand) cites 0.05 per cent concentration as germicidal in air. Hill & Aeberly (*Heating and Ventilating Magazine*, February, 1922), report noticeable bacteriacidal effects in concentrations ranging from 300 to 450 ppm by volume. Ozone, even in respirable concentrations, is effective in inhibiting the development of fungi in cold storage; however, its action is inhibitory and not destructive.

ODORIFEROUS SUBSTANCES

T. Graham has pointed out that odoriferous substances are susceptible to oxidation. It is further known that most odoriferous substances contain unsaturated valencies, which render them particularly susceptible to attack by ozone.

The so-called odors of animal effluvia, frequently encountered in crowded places and where a large percentage of the air is recirculated, consists of low oxidation gases, and while present only in vanishingly small quantities, are highly odoriferous. These gases are completely and rapidly oxidized to odorless and innocuous products by ozone.

Hydrogen sulphide is thrown off in small quantities by man, and is frequently present in the air in relatively large quantities, as the result of many industrial operations. Ozone oxidizes hydrogen sulphide very rapidly; under some conditions to sulphuric acid and under other conditions to free sulphur and water.

Products of putrefaction, such as trimethylamine, indole, skatole, the mercaptans, etc., are readily oxidized by ozone, as are the odors arising from foods, especially during cooking. Many of the odors resulting from the combustion of organic matter are destroyed. The odor of pyridine in tobacco smoke is destroyed and not masked by ozone. Sulphurous gases produced by the combustion of coal are completely oxidized, while many of the unsaturated gases resulting from the incomplete combustion of natural gases, oil and spirit fuels, are deodorized by ozone.

Carbon monoxide is but slowly oxidized to the dioxide, the reaction being accelerated by the presence of a catalyst and also at elevated temperatures. However, the molecular concentrations of ozone must be comparable, and preferably in excess of, that of the CO, in order to obtain reaction velocities of sufficient value for practical purposes.

In garages and testing rooms the air is frequently contaminated with gasoline vapors and unsaturated gases, resulting from incomplete combustion, which cause headaches and feelings of lassitude. Ozone is valuable in oxidizing these gases and freeing the air from odor. However, CO must always be taken into consideration. It is an odorless and very insidious poison, since the victim has little warning of his condition until coma is induced. Four parts of CO per ten thousand of air is the maximum concentration which may be respired continuously without noticeable effect. (Henderson, Yandell, et al—*Journal. Ind. Hyg.* Vol. 3, 1921). Carbon monoxide frequently has been found present in quantities much greater than four parts per ten thousand in the atmosphere of garages and the like, and so far, adequate ventilation is the only remedy known. It is obvious that, chemically, ozone has nothing to offer for carbon monoxide correction, since the reaction is, at best, slow in the absence of a catalyst, and a molecular concentration of ozone comparable with a lethal concentration of CO, would produce quite as much physical distress as the carbon monoxide. Carbon monoxide is the index of good garage ventilation; this factor may be favorable and still an odoriferous condition, causing minor distress, may attain. Here ozone is of value, but it must be used with judgment, and does not permit of a curtailment of any of the ordinary CO precautions. Ozone and ionized air may possibly have some physiological effect on the haemoglobin, which may cause a shift, in selectivity, in favor of oxygen, but to date knowledge on this subject is not available.

OZONE GENERATORS

The air actually passed through an ozone generator should be free from water vapor, dust and gases normally foreign to the atmosphere. Rideal (Ozone, D. Van Nostrand) states that a relative humidity of 25 per cent, and a dry-bulb temperature of 68 deg. fahr., limits the yield of ozone 60 to 70 per cent of that which would be produced with dry air, other conditions being equal. The vapor content of air to be ozonized should not exceed 0.1 grain per cubic foot for the best results.

The presence of sulphur dioxide, nitrogen dioxide, chlorine, etc., appreciably reduces the efficiency of an ozonizer. Ammonia gas, should it be admitted to the ozone generator in appreciable quantities, may cause an explosion.

The presence of dust favors the passage of sparks, which cause thermal decomposition of the ozone, and adds to the formation of oxides of nitrogen. Ozone generators are now generally supplied with an air filter.

Sparking and creeping discharges, which frequently form at the edges of the electrodes, should be prevented by the proper design of the electrode members.

The rate of decomposition of ozone is greatly accelerated at high temperatures, therefore, ozonizers should be operated with a minimum temperature rise. At room temperatures the rate of decomposition is negligible.

Due to the catalytic effects on the decomposition of ozone, inherent in commercial ozonizers, there is a decided limiting concentration at which ozone may be produced. As a rough approximation, it may be stated that the rate of decomposition is proportional to the concentration of ozone. Thus, the energy necessary to produce high concentrations is much greater than that required to produce the same weight of ozone in a more dilute state. The rate of air flow, to energy input, determines the concentration; therefore, air flow is a very important factor in ozonizer design. However, it must be pointed out that the yield does not increase indefinitely, with increasing air flow; and since the power required to dry the air is considerable, in relation to the power required to produce the quantities of ozone used in ventilation, it becomes necessary to strike a compromise between these two costs, in order to obtain the lowest gross cost of production.

Hill & Aeberly (*Heating and Ventilating Magazine*, December, 1921), have published graphs showing the relation between yield of ozone and air flow, while Hartman (*Ice & Refrigeration*, November and December, 1924), has given a detailed analysis of this factor in the terms of dollars and cents.

QUANTITATIVE ANALYSIS

Ozone, in air, is best determined quantitatively by iodimetric titration. Of the numerous methods for the quantitative determination of ozone that have been advanced from time to time, none combine as high an order of accuracy with simplicity of technique, as does this standard method, the technique of which is familiar to all chemists or may be found in any textbook of volumetric analysis.

As the output of an ozonizer can be very closely controlled by the manufacturer, it is recommended that the output be checked, when desired, by an analysis of the ozonized air coming directly from the ozonizer, thus eliminating the errors inherent in fan deliveries, leakage, etc., which may be additive and of sufficient magnitude to give quite an erroneous idea of the performance of the ozonizer.

It is frequently desirable to determine the concentration of ozone actually produced in the spaces for which the ventilation is intended. Such concentrations are generally of the order of 0.01 ppm minimum, to about 0.5 ppm maximum, and are without the range of accuracy of the standard iodimetric method. A fairly accurate, and comparatively simple, method for determination of concentrations of this order has been devised by Yant, Jones & Houghten, which is described in detail in the TRANSACTIONS, A. S. H. V. E., Vol. 29, 1923, p. 331.

Periodic checks of the actual output of the ozonizer, together with a check of the concentration established in the ventilated spaces should be fruitful of exceedingly interesting and suggestive data.

PROPER CONCENTRATION OF OZONE

The concentration of ozone in the air of ventilated spaces, should not be allowed to rise appreciably above 0.01 ppm. However, this does not mean that this is the proper concentration to introduce. The quantity of ozone necessary to maintain this concentration will depend upon what has been aptly termed "respiratory load," or cubic feet of air, per person, per unit of time; together with a consideration of such odoriferous operations as may exist in the ventilated spaces, and the purity of the source of air supply. Thus air drawn from near the level of the city streets will require more ozone to maintain the proper concentration, than will air drawn from purer sources. This applies equally to air drawn from the vicinity of stock yards and the like.

Likewise restaurants, smoking rooms, dance halls, and theaters will require a greater quantity of ozone than will schools, offices, etc. Department stores, particularly the basements, due to odors arising from fabrics and other wares, require special consideration. There is also what may be called the "building coefficient," which includes the length of the duct system, the heights of the ceilings, and the condition of the ventilating system, whether old and dusty or new and clean, together with the rate of air change, and whether humidity control is provided or not.

In industrial ventilation, where specific contaminants are to be contended with, a knowledge of the concentration and character of the contaminating substances is essential for best results. Ozone is not a cure-all for industrial odors in general, for instance, allyl alcohol vapors, which possess an annoying odor, when subjected to action with ozone, produce the aldehyde acrolein, which is exceedingly irritating, even in very small concentrations. Here harm rather than good will be done. It is best to submit problems of this character to engineers experienced in the use of ozone for definite recommendations.

It has been recommended (Hill & Aeberly, *Heating and Ventilating Magazine*, March, 1922) that sufficient ozone capacity be provided to permit of building up comparatively high concentrations when the building is not occupied. In schools, for example, the ozone equipment should be operated at a capacity to give perhaps 0.01 ppm of ozone when the building is occupied, and after the pupils have left the building, the full capacity of the machine should be used, closing all openings, recirculating the entire amount of air, and building up a sufficient concentration to exert the maximum deodorizing effect throughout the building, the duct work and mechanical equipment.

For general ventilation, under average conditions (85 per cent ventilation), the ozonizer should be of sufficient capacity to provide a concentration of 0.05 ppm of ozone in the fan volume. For 100 per cent ventilating systems a lesser quantity can be made to suffice. A generalization cannot be made broad enough to cover the many special conditions, particularly problems of specific deodorization.

Capacity of Ozonizers

Having chosen the maximum required concentration of ozone, for the purpose in hand, it becomes necessary to calculate the capacity of the ozonizer. There seems to be no agreement, among makers of ozone equipment, regarding the unit of rating for ventilating ozonizers. There are three methods in common use, as follows:

Parts per Million: Wherein the ozonizer is rated in parts per million (generally by volume) in some specific air volume. At first this may seem a very desirable method for rating ozonizers, as it is simply necessary to state the ppm of ozone, required for the specific CFM of air. Ozonizers so rated, have their ozone meter calibrated in ppm for the specified CFM, and should the fan volume be varied, the meter is liable to become misleading, as the original CFM may not always be considered when reading it. Consideration of the original CFM, and proportioning to any new CFM, is essential with an ozonizer so rated, if accurate knowledge of the concentration employed at any other CFM is desired.

Ozone is generally applied on the basis of ppm by volume, and as there is no existing agreement concerning a standard temperature and pressure at which the ozonizer should be calibrated, this method of rating leaves the actual capacity of the unit open to question, unless the temperature and pressure employed for calibrating is stated. Since weight is unaffected by temperature and pressure, and as ozone is determined chemically, directly in the terms of weight, weight forms a better basis for the rating of ozonizers, and eliminates a number of qualifying factors, together with tedious calculations in ozonizer design.

Milligrams per Minute: Ozonizers so rated have their ozone meter calibrated directly in the terms of milligrams per minute, and leave no questions concerning the actual capacity of the unit. Errors of omission are further circumvented by forcing a consideration of all factors, when determining the concentration of ozone in the air of the ventilating system.

The expression ppm, generally means parts per million by volume at room temperature and average barometric pressure, when referred to ozone in ventilation. One litre of ozone at 25 deg. cent. and 740 mm Hg, weighs 1.9127 grams. Taking these conditions as a basis, the weight of 1 cc. of ozone may be taken as 2 milligrams, yielding a very convenient figure for use, easily remembered, and sufficiently accurate for all practical purposes. The metric system is best employed here, for convenience of analysis and calculations of design, with final conversion into English units for purpose of application. It is on this basis that the following formulae have been derived:

Formulae for Application:

CFM = fan capacity, cubic feet per minute of air.
mpm = milligrams of ozone per minute.
ppm = parts of ozone per million parts of air, by volume, at 25 deg. cent. and 740 mm. Hg.
28,320 = cc per cubic foot.
2 = weight of 1 cc of O_3 at 25 deg. cent. and 740 mm. Hg.

Given: CFM and ppm; Find, mpm:

$$\frac{\text{CFM} \times \text{ppm}}{10^6} \times 28{,}320 \times 2 = \text{mpm}$$

which reduces to:

$$\frac{\text{CFM} \times \text{ppm}}{10^3} \times 56.64 = \text{mpm} \quad \text{(1)}$$

Given: mpm and ppm; Find, CFM:

$$\frac{\text{mpm} \times 10^3}{56.64} \times \frac{1}{\text{ppm}} = \text{CFM} \quad \text{(2)}$$

Given: mpm and CFM; Find, ppm:

$$\frac{\text{mpm}}{56.64} \times \frac{10^3}{\text{CFM}} = \text{ppm} \quad \text{(3)}$$

Ventilating Unit: The Ventilating Unit (VU) has been created by the author, for the purpose of simplifying the calculations for applying ozone to ventilating systems. It is a compound unit, taking into consideration quantity and time. It is analagous to the horsepower, wherein 33,000 lb. are lifted one foot in one minute. It represents that quantity of ozone necessary to produce a concentration of 0.1 ppm in 1,000 CFM, at 25 deg. cent. and 740 mm Hg.

1 VU = 5.7 milligram of O_3 per minute
340 milligrams of O_3 per hour

The formulae for its application are very simple:

Given: CFM and ppm; Find, VU:

$$\frac{\text{CFM}}{100} \times \text{ppm} = \text{VU} \quad \text{(4)}$$

which reduces to pointing off two places in the CFM and multiplying by the ppm.

Given: VU and CFM; Find, ppm:

$$\frac{0.1 \times \text{VU}}{\text{CFM}} \times 1{,}000 = \text{ppm} \quad \text{(5)}$$

which reduces to pointing off three places in the CFM, one place in the VU, and dividing the former into the latter.

Given: VU and ppm; Find, CFM:

$$\frac{1{,}000}{\text{ppm} \times 10} \times \text{VU} = \text{CFM} \quad \text{(6)}$$

As the VU represents a definite weight of ozone, in a definite period of time, ozonizers so rated leave no question as to their actual capacity. The decimal character of the unit admits of much facility in calculations.

METHOD OF APPLICATION

In order that ozone may be made from properly conditioned air it becomes necessary to produce it in relatively high concentrations, which are introduced into the fan intake where mixing and dilution to proper strength is accomplished. The highly concentrated ozonized air is conducted in either brass or aluminum pipe from the ozone generators to the ventilating fan, the pressure required for delivering it being supplied by the blower furnished with the ozone machine. It is best to locate the ozone machine as near the ventilating fan as practical and in no case should the friction of the ozone delivery pipe exceed one pound per square inch. For typical layout, floor space, electric service, etc., covering general ventilating practice, refer to the catalog data section. It is frequently advisable to interlock the operation of the ozone machine with the ventilating fan so that the starting and stopping of the fan also starts and stops the ozone machine automatically. When the respiratory load (*i.e.* number of people occupying the ventilated spaces) is subject to wide and rapid variation, it is advisable to provide means for both observing and controlling the quantity of ozone being produced, at some point convenient to the ventilated spaces, so that an attendant can synchronize the ozone production with the respiratory duty of the system. This is particularly advisable for restaurants, theaters, dance halls and the like.

When a number of ventilating fans in one building are grouped so that all may be supplied from one ozone machine, a multi-unit ozonizer should be employed, thus centralizing the equipment and permitting the use of a common air drying plant. These multi-unit assemblies should be so designed that each unit can be controlled independently and remote control of ozone output as well as automatic synchronism with the operation of the ventilating fan can be provided for each unit of the assembly.

Ozone machines should be provided with an indicating ozone meter for registering the quantity of ozone being produced at any instant. This meter should be operated by the net electrical energy input, as meters operating on pressure or current are unreliable and frequently misleading.

REFERENCES

Ozone, By E. K. Rideal.

Puschin & Kauchtschev, J. Russ, *Physiological Chemistry Society*, 46, 576, 1914.

Bulletins, U. S. Bureau of Mines.

Industrial Applications of Ozone, By F. E. Hartman (Journal, A. S. H. V. E., November, 1924, p. 711).

Ozone and Its Use in Ventilation, By F. E. Hartman (Journal, A. S. H. V. E., May, 1924, p. 365).

Improving Air in Rooms by Means of Ozone, From Lubbert, Uber die Gesundheitsshadlichkeit der Luft bewohnter Raume und ihre Verbesserung durch Ozon, Gesundh-Ing., 1907.

Experiments on Air Improvement, By Erlander and Schwartz, Experimentelle Untersuchungen uber Luftverbesserung, Zeit. Hyg. Infektionskrankh, 1912.

Experiments on Deodorizing, By Kisskalt, Versuche uber Desoderierung, Ebenda.

Application of Ozone in Ventilation, By Konrich, Zur Verwendung des Ozons in der Luftung.

Forced Ventilation in St. Louis Schools, By E. S. Hallett, *Domestic Engineering*.

Hill & Aeberly, *Heating and Ventilating Magazine*, December, 1921.

CHAPTER 31

SPECIAL HEATING AND VENTILATING APPLICATIONS

Brief Summary of Special Factors to be Considered for Greenhouse Heating; Barn Ventilation; Government Buildings; Cold Storage Warehouses; Schoolhouses; Spray Booths; Pressing Rooms and Libraries.

GREENHOUSE HEATING

IT is important that the heat shall be defused evenly, that there shall be no high-velocity air currents, especially for flowers, and that no rapid temperature fluctuation shall be permitted.

Steam and hot water systems both are used in greenhouse heating. Electrically propelled unit heaters have been used with good results. Unfortunate results occasionally are encountered with all of these different kinds of apparatuses.

Table 1 gives the usual temperatures required in greenhouses. The heat losses from greenhouses are computed the same as are the heat losses from other types of building. The service is for 24 hours per day, and the peak demand occurs when the weather is cold and there is no sunshine, as at night. Leakage of air through cracks in the glass frames is not serious since in cold weather these freeze due to condensation, and seal tightly with ice. The boiler in a greenhouse must always be selected on the basis of the heat demand and will seem large in proportion to the square feet of radiation, since greenhouse radiators or convectors usually are highly efficient. The piping, where direct heaters are used, is designed usually with a view to the kind of plants to be grown, though there is some tendency to use side wall and free hanging overhead heating surface in preference to piping under the plant benches.

It is probable that there are more low-pressure steam heating systems in greenhouses than any other kind of system. It is highly desirable that with such plants there shall be vacuum pump returns, with thermostatic heater traps. It is important, whatever the type of system, that the heating surface or out-put be well subdivided, so that no matter how much or how little heat shall be needed, just enough and no more than enough can be delivered. The heat must be distributed just as evenly over the whole area of the greenhouse as though all of the output were being delivered. One recommendation is that the heating surface be subdivided and provided with valves in increments of not exceeding 10 per cent.

The openings in the roof of a greenhouse which serve for ventilation are arranged in a row along the ridge and are spaced uniformly. If pipe

TABLE 1. USUAL TEMPERATURES REQUIRED IN GREENHOUSES

KIND OF VEGETATION	TEMPERATURE REQUIRED, DEG. FAHR.
Violets Camelias Azaleas Lettuce	40 to 45
Cool Palm Houses Carnations	50 to 55
General Purposes Roses Mushrooms	55 to 60
Forcing Houses Conservatories Orchid Houses Fern Houses	60 to 65
Peach House Vinery Early Tomatoes and Cucumbers Tropical Palm House	65 to 70

coils are arranged lengthwise of the house they must be heated evenly and proportionately to the cooling effect of the ventilation. However, in practice excess radiation must always be placed at the ends of the house to compensate for the extra heat losses at the gable ends. The result is that when the roof ventilation is open, the ends of the building tend to over-heat. Any small leakage of supply valves or return traps also tends to cause over-heating of the ends of the long coils. A curious observation is that the air in a greenhouse tends to move in a direction opposite to that of the wind outside. This causes over-heating of the windward end and under-heating of the leeward end. This reverse interior current also causes a lowered relative humidity at the leeward end and excess moisture at the windward end; since such leakage as there is tends to enter from the leeward end.

In one case when unit heaters with electric fans were installed in a rose greenhouse, observations with thermometers and humidity instruments indicated excellent results, but the roses would not grow until the air velocity from the unit heaters was reduced to a very gentle current. The most recent testimony seems to indicate that in general, when steam is used the electric unit heater is satisfactory, using low velocities of air and rather close spacing of the heaters.

All successful greenhouse operators testify that great manual effort and exceedingly detailed attention must be applied to the air conditioning. There is a demand for very reliable automatic temperature control. One State University reports most favorable results with unit heaters and electric automatic control.

There is no question but that forced circulation hot water heating finds an especial field in greenhouse work, since the heaters may be almost as si[illegible] those used with steam, and since the temperature of the heati[illegible]ace may be controlled within such a wide range either by therm[illegible] or by hand, without the constant adjusting of supply valves necessary when steam is used.

DAIRY BARN VENTILATION

Th[illegible]ving are the salient requirements of dairy barn ventilation:

1. [illegible] ventilation, there should be provided about 3,500 cu. ft. of fresh air per hour per 1[illegible]0 lb. of live stock weight.

2. [illegible] convective circulation is generated by the heat from the bodies of the stock, [illegible] an upward movement toward the ceiling, about them, and a consequent downward movement at the walls.

3. [illegible]penings should be located in the walls near the ceiling so that incoming cold a[illegible] toward the floor, will accentuate the convective action induced by the heat with[illegible]

4. [illegible]penings seem to function merely as exhaust ports, to relieve the interior pressu[illegible]ppear to have little influence on the direction of air currents. Hence, the spacin[illegible]ribution of outlet openings is rather immaterial, so long as the required aggre[illegible] is provided. Area of outlet openings should be about one-third greater than intal[illegible]

5. [illegible]er to take the air out at the floor than at the ceiling, since by the former there [illegible]o be a larger volume of warm air held in the stable, which contributes to better temperature control.

6. T[illegible]e circulation resulting from the down-flowing cold air entering at openings in [illegible]s near the ceiling, cooperating with the convective action induced by the heat o[illegible]nimals, effectually prevents condensation and keeps the air fresh and odorless.

DES[illegible] AND OPERATING DATA FOR MECHANICAL EQUIPMENT OF GOVERNMENT BUILDINGS

THE [illegible]E, 1929, contains a chapter on this subject by N. S. Thompson of the [illegible]ury Department. It contains data on the proportioning of plumbi[illegible]tures, sewers, water services, fire protection, etc. It also gives ro[illegible]pproximations for determining the wattage for illumination, the nu[illegible]f elevators and the amount of heating surface in radiators. Data is [illegible]n covering the average fuel and labor and maintenance costs for abo[illegible]00 Treasury Department Buildings. The following is quoted therefrom[illegible]

> Rough[illegible] lb. of coal per cubic foot is required per year for heating the ordinary building[illegible]n buildings containing electric generating plants 1 lb. of coal per cubic foot is a[illegible]ately correct for all purposes. Roughly, the maximum electrical demand in the la[illegible]dings averages $^{6}/_{10}$ k.w. per square foot of gross floor area.
>
> For b[illegible]m repairs allow $2.00 per horsepower nominal rating.
>
> For [illegible]oom repairs allow $2.00 per annum per kilowatt total nominal rating of generato[illegible]
>
> For [illegible] engine room supplies allow $2.00 per annum per horsepower of boilers installed.
>
> Boile[illegible]bor averages $2.00 per ton of coal fired, based on an 8 hour shift and 48 hours per week.
>
> Ash [illegible]verages $\frac{1}{5}$ of a cubic yard to each ton of coal burned and is estimated to cost $1.00 per cubic yard to remove it.
>
> The [illegible] Federal Building containing an electric generating plant will roughly averag[illegible] as the cost of the coal, supplies and repairs to the boilers and electric generators.

The fixed charges for machinery in a Federal Building are 3 per cent interest and 5 per cent depreciation per annum on engines, boilers, etc., while on buildings, tunnels, etc., 2 per cent depreciation per annum is allowed.

The annual dividend which must be earned by the ordinary isolated Federal plant in comparison with the purchase of current from a public utility company is 10 per cent on the cost of the Government plant.

HEAT EXCHANGERS FOR WATER AND OIL

A valuable chapter on the subject of heat exchangers, giving the mathematics of this interesting thermal process, is included in The Guide, 1929.

VENTILATION OF COLD STORAGE WAREHOUSES

Fruit and vegetables are alive until they begin to decay and if they are to remain alive and well they must be given an ample supply of air and favorable humidity conditions. Conclusive demonstration has been made of the necessity of controlled ventilation for rooms in which fruit and vegetables are stored, even though the temperature in such rooms may be kept very low. It is possible to obtain well developed proprietary systems of ventilation for cold storage warehouses, and as the volume of air to be changed may be comparatively small, the cost for extra refrigeration due to ventilation is trifling, and often is more than compensated for by the improved interior air circulation and the elimination of air-stratification.

Warehouses for fruit storage where no refrigeration is employed should have many doors and windows, which may be opened during the night in warm weather, and closed during the day. The product should be piled in such manner as to allow very free air circulation between the cases and around them. Fans for driving new air quickly through and around the cases often are employed to good advantage.

ZONING OF HEATING AND VENTILATION

All alert engineers are paying more and more attention to the control of heating and ventilating equipment with reference to the changing daily outside conditions.

The larger schools in Toledo, have for years been provided with central manual control whereby the heating may be accentuated on the colder sides of the building, or reduced on the warmer sides of the building, in addition to the usual local thermostatic control. Substantial savings in the fuel cost of hotels and apartment houses and office buildings are often made possible by means of control by zones. It is possible that much of the fuel saving by this zoning is affected by the prevention of too many open windows on the leeward or sunny sides of the building.

Remote controlled electrically or pneumatically-operated valves are obtainable, and the design of any large building which has no provision for zoned operation is subject to criticism. The various remote supply valves may be operated by thermostats or may be under manual control, or by throwing one switch either type of control may be selected. It is possible also to indicate at a central point, accurately and at low cost, the temperatures throughout the building, which information of course furnishes the inspiration for use of the manual controls. The effect of sunshine on building heat-demand may thus be followed around the building each day.

A further, very simple refinement may cause the fuel-burning device, such as stoker or oil burner or gas flame to be shut down whenever the last zone valve closes, and to resume operation whenever the first zone valve opens, no matter which one this may be.

VENTILATION OF LACQUER SPRAY BOOTHS

In general there must be an exhaust fan which will provide an air velocity of at least 150 lin. ft. per minute through the opening into the hood from the room. It is preferable in installations of this type to use a pressure fan with an inductor-jet or nozzle so that the carried-away lacquer does not enter the fan at all. It is proper to make the exhaust duct in the vicinity of the booth of such type that accumulations of paint may be removed when they begin to clog the air ways.

In many automobile body spray booths the ducts for exhausting from the spray hood will range from 30 to 48 in. in diameter. A 30 in. duct usually requires about 2 hp. for the fan, which maintains on the 5 in. nozzle pipe, pressure equal to a column of water about 7 in. high. For a 48 in. duct the fan requires about 5 hp. and the pressure is 10 in. of water on a 6½ in. nozzle pipe. There are proprietary systems of this type.

VENTILATION OF PRESSING ROOMS IN MEN'S CLOTHING FACTORIES

In the men's garment manufacturing industry there are used large batteries of clothes pressing machines.

These usually have large heated areas filled with high pressure steam, and the heaters and the piping which serves them and the jets of steam used on some of the machines for direct application to the cloth, bring about a man-cooling problem of considerable extent. The following solution has been found reasonably satisfactory for use during warm weather:

1. Mechanical exhaust ventilation of about 2,000 cu. ft. per minute per machine, with gravity inlets through ducts, doors, windows, etc.
2. Mechanical supply ventilation taking air from out-of-doors, delivered horizontally directly toward the face and breast of each operative through an adjustable nozzle of about one-half square foot area at a velocity of about 800 lin. ft. per minute. This nozzle should be about 2 ft. from the man.
3. The inlet to the mechanical supply ducts should be taken if possible from the north or shady side of the building, or from a shaded court, never from above a sunny black roof, since the normal out-door air will gain considerable heat when drawn into the building over such a surface.

AIR CONDITIONING OF LIBRARIES[1]

Temperature, per se, can be disregarded generally as having little effect upon the keeping qualities of books. There is an optimum temperature for the growth of each variety of mildew, but this growth can best be inhibited by depriving the mildew of water or by the use of chemical treatments. Too high a temperature (over 100 deg. fahr.), combined with low relative humidity, may cause the book materials to become brittle. A temperature much below freezing (25 deg. fahr.) may cause permanent deterioration of the glue.

---

[1] Based on a paper by the Bureau of Standards.

The relative humidity should be maintained between 40 per cent and 70 per cent, although these limits may be exceeded in either direction for short periods of time. If the relative humidity gets much below 40 per cent, first the glue and then the paper will tend to become brittle. This will not cause any permanent damage unless the book is used, or rather abused, while in this condition. Subsequent increase in humidity will bring the materials back to their normal condition. If the relative humidity gets much above 80 per cent, the growth of mildew may be expected.

The tendering, brittleness, and yellowing of books, which are usually looked upon as signs of age may be caused by oxygen plus moisture or by sulphuric acid. The effects can be diminished by using a grade of paper which is as nearly pure cellulose as practicable. The deterioration of the leather bindings can be retarded by occasional applications of neats-foot oil. Sometimes leather and paper contain small amounts of sulphuric acid, put in during the manufacturing process. Such leather or paper is not so suitable for book making as that which is entirely free from acid. The glue used in making books should contain a preservative to prevent any decomposition from the growth of bacteria or mildew. It should also contain some plasticizing agent, such as glycerol, to offset the effect of exposure to low humidity.

Books should be protected, as far as possible, from exposure to direct sunlight, since this accelerates the deteriorating action of other agencies.

CHAPTER 32

SUMMARY OF IMPORTANT SPECIFICATION ITEMS

THE purpose of this chapter is to provide a suggested list for checking heating and ventilating specifications so that the important items covering work to be done, will be included.

INSTRUCTIONS TO BIDDERS

Proposals

1. Date, time and place of receipt of bids.
2. Sealed and labeled on outside as to the work covered and whom bid is from.
3. Where plans and specifications may be secured and as to deposit required.
4. List of the separate branches of work upon which bids will be taken.
5. Bid form—to be copied by bidders.
6. Amount of certified check or bid bond required with bid; terms of liability if bidder refuses or neglects to enter into a contract and return of certified checks or bonds.
7. How bids are to be signed.
8. Time allowance and other arrangements for signing contracts.
9. Right to reject bids.

Bonds

1. Kinds of bonds required, *i.e.*, for the faithful performance of the work, maintenance, payment of bills, damages, suits and claims, patent infringement and guarantees.
2. Obligation of sureties.

GENERAL CONDITIONS

Special Notice to Contractors

In case the heating and ventilating specifications are attached to and made a part of a general specification where general conditions cover all or many of the following items the ones covered may be left out and the following clause be added at the head of the heating and ventilating specification.

"The general conditions written for the entire work and appearing in the forepart of this specification apply to each and every contract, contractor, sub-contractor or other person or persons supplying any material or labor entering into this building, directly or indirectly. These general conditions govern all parts of the work and are parts of and apply in full force to the heating and ventilating work and other items as herein specified. The contractor shall refer thereto as forming integral parts of his contract."

Specifications, etc. Part of Contract

Specifications, plans, instructions to bidders, advertisement and proposal declared and made a part of any and all contracts.

Application

Clause stating that general conditions refer and apply to each and every contract or sub-contract covered by the specification.

Examination of Premises and Buildings

That all contractors must visit and examine or otherwise be responsible for existing conditions.

Approval of Sub-Contracts

Names to be submitted and approved before sub-contracts are let.

Time of Completion

1. Dates and methods of procedure for any special parts to be completed ahead of general completion.
2. Dates of final completion.
3. Liquidated damages.

Extension of Time

Conditions under which additional time will be allowed for completion; to compensate for time unavoidably lost; changes in contract requirements; delays by others, etc.

Extension of Time not a Waiver

Extension of time or occupancy of the premises in whole or in part not to constitute a waiver of the owner's rights.

Unit Schedule

To be furnished for each branch of the work, covering all items of material and labor and footing up to the contract price. For use in checking payments, costs of additional work or credits for work omitted.

Definition of Terms

Such as *Board*, *Committee*, *Owner*, *Architect*, *Engineer*, etc.

Cooperation

1. Between contractors and with owner as to changes, etc.
2. Rules governing relations between contractors as to water, gas, light, telephone, etc.

Supervision and Foreman

Provide for continuous supervision by parties satisfactory to Engineer and subject to removal if unsatisfactory.

Permits, Department Rules and Regulations

1. Compliance with Building, Plumbing, Health and Fire Departments having jurisdiction and with State Codes and rules and with the rules and regulations of the *National Board of Fire Underwriters.*
2. Any additional material or labor required to conform to any of these rules and regulations to be furnished under the contract without additional cost.
3. Contractor to secure all necessary permits and pay all fees incident thereto.

Extra Work

To be done upon written orders only, stating cost where possible, otherwise cost to be upon basis of schedule or prevailing market values.

Strikes

To be avoided if possible and settled with dispatch.

Patents

Contractor to assume responsibility and pay any royalties for use of patented articles.

Payments

When and how made. Final payment not binding as to defective work.

Guarantee

1. Regular guarantee.
2. Special maintenance or operation guarantees.
3. Defects other than normal wear and tear to be made good during the life of the guarantee.

Material and Workmanship

Quality of material and workmanship regardless of manufacturers' trade designations. Materials to be delivered in sufficient quantities; labor to be competent and both under control of the Engineer.

Samples

As required; to be submitted for approval.

Protection

1. Of materials delivered and work in place.
2. Of life and property, including warning signs, guards, watchman's service, etc.
3. Indemnify and save harmless the owner from any suits or claims arising out of alleged damages.

Insurance

Fire and tornado, liability on account of injury to persons or property.

Drawings and Specifications

1. To be used jointly and not separately.
2. Discrepancies to be called to the attention of the engineer before the work is installed.
3. Detail drawings.
4. Shop drawings; how submitted for approval.

Engineer's Supervision and Authority

1. All work under Engineer's supervision.
2. Interpretation of plans and specifications to be solely by engineers.
3. Power to manage work if contractor fails to do so satisfactorily.
4. Power to recommend the termination of the contract and employment of others to complete, if the contractor fails or neglects to properly progress work or abandon the work for three or more days.
5. Disposition of moneys in cases (3) and (4).

Tools and Appliances

All derricks, machinery, shoring, scaffolding and tools to be furnished and maintained by the contractor and removed by him at completion.

Cutting and Patching

1. By whom done.
2. This contractor to give to all other contractors dimensions, location and other data for chases, sleeves, boxes, etc., to be built in, and in time to prevent delays, otherwise to bear expense and responsibility for installing such items later.
3. Repairing and refinishing, as to whom done by and in what manner.

Rubbish and Cleaning

1. Removed by contractors depositing same.
2. Cleaning up building.
3. Cleaning ducts and flues.
4. Cleaning boilers and pipes.

Contract Drawings

List of contract drawings.

Symbols

List of symbols.

Scope of Work

1. Work included in contract.
2. Work by others.

Substitution

1. Not to be made after contract is signed.
2. Substitution must be offered five (5) days before bids, with full description and any difference in price; all other bidders to be allowed to bid on such substitution.

Testing and Trial Operation

1. Testing and adjusting.
2. Trial operation; number of days.
3. Instructions for operating.

Temporary Heat

1. Making available for temporary heating purposes any and all parts of the equipment installed, or which should have been installed at the time such heat is required, without extra cost.
2. Setting, connecting, disconnecting and reconditioning radiation for temporary heat as directed and cost per radiator for this work.
3. By whom fuel is to be furnished.
4. Terms under which contractors shall furnish labor to operate, with option for owners to operate.
5. Contractor to assume all responsibility for system while being used for temporary heat.

GENERAL DESCRIPTION OF AND SPECIFICATIONS FOR THE WORK

General Description

1. Method of heating building.
2. Method of ventilating building.
3. Control for heating and ventilation.
4. Water heating equipment.
5. High-pressure steam, low-pressure steam, feed water, service water, fire protection, refrigerating, compressed air, drip and drain piping systems.
6. Provisions for future extensions.
7. Are pipes to be concealed or exposed?

Boilers

1. Number.
2. Size.
3. Foundations.
4. Encasement.
5. Kind of fuel—grates, stokers, oil burners, gas burners.
6. Controlling and observing instruments and equipment; damper regulator.
7. Trimmings—safety valves, blow-off valves, water columns, gages, etc.
8. Firing and cleaning tools, soot blowers, brushes.
9. Test and insurance.
10. Working pressure.
11. Connections—water, gas, oil, blow-off, electric, etc.

Smoke Breeching

1. Gage of steel.
2. Cleanout doors.
3. Dampers.
4. Supports and provision for carrying insulation.

Chimney

1. Size and height.
2. Lining.

Fuel Storage and Handling

Coal truck, conveyors, oil tank, gages, etc.

Ash Storage and Handling

1. Ash cans, truck, etc.
2. Ash conveyor, elevator, hatches, etc.

Blow-off Tank

1. Size and construction.
2. Connections to sewer, cooling arrangements, etc.

Hot Water Generating Apparatus

1. Capacity in gallons and size of tanks.
2. Kind and capacity of heating surface.
3. Supports.
4. Thermometers, temperature controls and relief valves.
5. Coal, gas, steam, inserted coil, attached circulator, etc.
6. Relief and safety provisions.

Pumps

1. Function.
2. Number, size, motive power.
3. Trimmings, gages, valves, etc.
4. Connections.

Tanks

1. Function.
2. Number, size, supports.
3. Trimmings, gages, valves, etc.
4. Connections.

Pipe, Fittings, Etc.

1. Kinds and weight of pipe and nipples.
2. Kinds of fittings and working pressure.
3. Expansion and contraction and anchoring arrangements.
4. Thimbles, sleeves and plates.
5. Supports.

Valves

1. Kind and working pressure with schedule.
2. Special valves, such as pressure regulating, remote control, automatic stop and non-return.
3. Operating devices, such as extension handles and chains.
4. By-pass provisions.

Traps and Air Valves

1. Kind and make.
2. Cleaning, as for vacuum traps.

Radiators

1. Kind and legs, or legless.
2. Tappings.
3. Supports, as for ceiling radiators, pipe coils, etc.
4. Concealed heaters and grilles, dampers, encasement, valves, etc.
5. Radiator recesses and grilles, linings, hoods, etc.
6. Pipe coils.

Fans

1. Number, make, type, size, etc.
2. Hand and housing.
3. Capacity and pressure.
4. Direct connected or belted.
5. Bearings, pulleys, extended shafts, etc.
6. Foundations and sound proofing.

Blast Convectors

1. Type.
2. Make.
3. Number of rows and arrangement.
4. Square feet of heating surface and free area.
5. Cubic feet of air to be heated and temperature range.
6. Method of control of temperature.
7. Foundations and supports.

Air Conditioning

1. Type.
2. Capacity.
3. Guarantee.
4. If air washers, describe humidity control, gage and kind of metal for tank, casing, eliminators. Also pump piping, valves, gages, strainers, spray-heads.
5. If filters, describe type, motive power, control, gages, housing, etc.

Motive Power

1. Kind, with schedule of power and speed of each unit.
2. Controlling, starting and protective devices.
3. Electric connections.
4. Foundations, sound proofing, etc.

Insulation

1. What is to be insulated?
2. Description of various kinds of insulation.
3. Insulation of the building structure.

Sheet Metal Work and Ducts

1. Gage and kind of metal.
2. Joints and seams.
3. Stiffeners and supports.
4. Access doors.

5. Encasements and housings.
6. Inlet and outlet hoods, louvers, etc.
7. Dampers.

Registers and Grilles and Diffusers

1. Where required.
2. Kinds, material, design, etc.
3. Finish.
4. Define where registers with louvers in back and where plain grilles without louvers are to be used.

Unit Ventilating Machines

1. Type and capacity.
2. Control of output.
3. Type of electric current, wiring, switches, etc.
4. Intake hoods, dampers and control.
5. Auxiliaries, as humidifiers; dust filters, etc.
6. Sound proofing.

Unit Heating Machines

1. Type and capacity.
2. Control of output.
3. Pipe connections, valves, traps, etc.
4. Type of electric current, wiring, switches, etc.
5. Sound proofing.

Belts, Chain Drives, Etc.

1. Make.
2. Number.
3. Size and thickness.
4. Speeds and horsepower to be transmitted.

Automatic Heat Control

1. Make and kind of system.
2. How blast convectors are to be controlled.
3. How dampers are to be controlled.
4. Piping or wiring.
5. Schedule of thermostats, valves and dampers.

Indicating and Recording Equipment

1. Thermometers.
2. Pressure gages.

Equipment for Maintenance

1. Tools.
2. Packing.
3. Lubrication.

Underground Piping

1. Material.
2. Supports, anchors and expansion devices.
3. Insulation and covering.
4. Drainage and waterproofing.

Trenches and Trench Covers

1. Furnished by whom.
2. Material, size, etc.
3. Provision for drainage.

Railings, Machinery Guards, Bird Screens, Etc.

1. Material.
2. Method of fastening.

Painting

1. What is to be painted.
2. Materials and workmanship.
3. Painting of insulation.

CHAPTER 33

PHYSICAL UNITS, WEIGHTS, MEASURES AND TABLES

MODERN engineering practice depends upon the correct application of basic principles already developed. This chapter contains definitions of fundamental units and tables of physical constants used by the heating and ventilating engineer.

UNITS, WEIGHTS AND MEASURES

One British thermal unit (B.t.u.) = $\frac{1}{180}$ of the heat required to raise the temperature of 1 lb. of water from 32 deg. to 212 deg. fahr. This is substantially equal to the quantity of heat required to raise 1 lb. of water from 63 deg. to 64 deg. fahr.

One mean calorie = $\frac{1}{100}$ of the heat required to raise 1 gram of water from 0 deg. to 100 deg. cent. This is substantially equal to the quantity of heat required to raise one gram of water from 17 deg. to 18 deg. cent.

One mean calorie = 0.003968 B.t.u. = 3.085 ft. lb. = 0.0011626 w.hr.

Power, Work, Etc.

1 ton refrigeration	= 199,038 B.t.u. per minute (approx.)
Latent heat of ice	= 143.33 B.t.u. per pound.
1 B.t.u. (British thermal unit)	= 777.5 ft. lb. = 0.293 watt hours. 252.02 mean calories.
1 watt hour (w.hr.)	= 2,655.4 ft. lb. = 3.415 B.t.u.
1 kilowatt (1,000 watts) (kw)	= 1.3405 horsepower = 56.89 B.t.u. per minute 44,236.5 ft. lb. per minute.
1 horsepower (hp.)	= 0.746 kilowatt
1 mech. horsepower	= 42.44 B.t.u. per minute. 33,000 ft. lb. per minute.
1 boiler horsepower	= 33,523.7 B.t.u. per hour or evaporation of 34.5 lb. of water per hour from and at 212 deg. fahr.

Weights and Volume

1 gal. (U. S.)	= 231 cu. in. = 0.13368 cu. ft.
1 British or Imperial gallon	= 277.274 cu. in.
1 cu. ft.	= 7.4805 gal. = 1,728 cu. in.
1 cu. ft. water at 60 deg. fahr.	= 62.37 lb.
1 cu. ft. water at 212 deg. fahr.	= 59.76 lb.
1 gal. water at 60 deg. fahr.	= 8.34 lb.
1 gal. water at 212 deg. fahr.	= 7.99 lb.

1 pound (avoir.) = 16 oz. = 7,000 grains.
1 bushel = 1.244 cu. ft.
1 short ton = 2,000 lb.
1 long ton = 2,240 lb.

Pressure

- 1 lb. per square inch =
  - 144 lb. per square foot.
  - 2.0416 in. mercury at 62 deg. fahr.
  - 2.309 ft. water at 62 deg. fahr.
  - 27.71 in. water at 62 deg. fahr.
- 1 oz. per square inch =
  - 0.1276 in. mercury at 62 deg. fahr.
  - 1.732 in. water at 62 deg. fahr.
- 1 atmosphere (14.7 lb. per square inch) =
  - 2,116.3 lb. per square foot.
  - 33.947 ft. water at 62 deg. fahr.
  - 30 in. mercury at 62 deg. fahr.
  - 29.92 in. mercury at 32 deg. fahr.
- 1 in. water at 62 deg. fahr. =
  - 0.03609 lb. or 0.5774 oz. per square inch.
  - 5.196 lb. per square foot.
- 1 ft. water at 62 deg. fahr. =
  - 0.433 lb. per square inch.
  - 62.355 lb. per square foot.
- 1 in. mercury at 62 deg. fahr. =
  - 0.491 lb. or 7.86 oz. per square inch.
  - 1.132 ft. water at 62 deg. fahr.
  - 13.58 in. water at 62 deg. fahr.

RELATION BETWEEN VELOCITY, ACCELERATION, TIME AND SPACE PASSED OVER

When the accelerating force is uniform the acceleration will be uniform. The velocity at the end of t seconds, if the body starts from rest, will be

$$v = at;\ \textit{whence}\ a = \frac{v}{t},\ \text{and}\ t = \frac{v}{a} \qquad (1)$$

The space passed over at the end of t seconds is equal to the product of the mean velocity and the time, or $L = \frac{1}{2}vt$, or $L = \frac{1}{2}at^2$.

The force of 1 lb. when applied to a mass whose weight is 32.17 lb. will produce an acceleration of 1 ft. per second per second when the mass is moving against no resistance (frictionless motion). A force of f pounds acting on a mass of 1 lb. will produce an acceleration of $f \times 32.17$ ft. per second per second.

The relation between force, mass, and acceleration is given by the equation $f = Ma = \frac{Wa}{g}$. Substituting the value of a in terms of v:

$$f = \frac{Wv}{gt} \qquad (2)$$

ABSOLUTE TEMPERATURE

Physicists employ what is known as the absolute scale of temperature, based on the so-called absolute zero of temperature, at which point no molecular vibration exists. This zero is conceived as 491.6 deg. fahr. below the melting point of ice, or 32 deg. fahr., it having been discovered that an ideal perfect gas would change in volume by $\frac{1}{491.6}$ of its volume at 32 deg. for each 1 deg. change in its temperature at constant pressure. Thus, if

TABLE 1. PROPERTIES OF SATURATED STEAM[a]

ABSOLUTE PRESSURE, LB. PER SQ. IN.	TEMPERATURE, DEG. FAHR.	VOLUME, CU. FT. PER LB.	WEIGHT, LB. PER CU. FT.	HEAT CONTENT IN B.T.U.		LATENT HEAT IN B.T.U.		ENTROPY		
				of Liquid	of Vapor	of Vaporization	Internal	of Liquid	of Vaporization	of Vapor
p	t	v''	$1/v''$	i'	i''	r	ρ	s'	$\frac{r}{T}$	s''
1	101.76	333.3	0.00300	69.76	1105.4	1035.6	973.9	0.1327	1.8448	1.9775
2	126.10	173.6	0.00576	94.02	1116.2	1022.2	957.9	0.1750	1.7452	1.9203
3	141.49	118.7	0.00843	109.38	1122.9	1013.5	947.6	0.2009	1.6862	1.8871
4	152.99	90.6	0.01104	120.9	1127.9	1007.0	939.9	0.2199	1.6438	1.8637
5	162.25	73.5	0.01360	130.1	1131.7	1001.6	933.6	0.2348	1.6107	1.8456
6	170.07	62.0	0.01614	137.9	1135.0	997.2	929.2	0.2473	1.5835	1.8308
7	176.85	53.7	0.01864	144.7	1137.9	993.2	923.6	0.2581	1.5603	1.8184
8	182.87	47.35	0.02112	150.8	1140.3	989.5	919.4	0.2675	1.5402	1.8077
9	188.28	42.41	0.02358	156.2	1142.5	986.3	915.6	0.2759	1.5223	1.7982
10	193.21	38.43	0.02602	161.1	1144.4	983.3	912.2	0.2835	1.5062	1.7897
11	197.75	35.16	0.02844	165.7	1146.2	980.5	909.0	0.2905	1.4916	1.7821
12	201.96	32.41	0.03086	169.9	1147.9	978.0	906.1	0.2969	1.4783	1.7752
13	205.88	30.07	0.03326	173.8	1149.4	975.6	903.2	0.3028	1.4659	1.7687
14	209.56	28.06	0.03564	177.5	1150.8	973.3	900.6	0.3083	1.4545	1.7628
14.7	212.0	26.81	0.03730	180.0	1151.7	971.7	898.8	0.3120	1.4469	1.7589
16	216.3	24.76	0.04038	184.3	1153.4	969.1	895.8	0.3184	1.4337	1.7521
18	222.4	22.18	0.04508	190.5	1155.7	965.2	891.4	0.3274	1.4153	1.7427
20	228.0	20.10	0.04976	196.0	1157.7	961.7	887.3	0.3356	1.3987	1.7343
22	233.1	18.38	0.05441	201.2	1159.6	958.4	883.6	0.3431	1.3837	1.7267
24	237.8	16.95	0.05900	206.0	1161.3	955.3	880.1	0.3499	1.3698	1.7197
26	242.2	15.73	0.06356	210.4	1162.8	952.4	876.8	0.3563	1.3570	1.7133
28	246.4	14.67	0.06817	214.6	1164.3	949.7	873.7	0.3622	1.3452	1.7074
30	250.3	13.76	0.07267	218.6	1165.7	947.1	870.7	0.3679	1.3340	1.7019
32	254.0	12.93	0.07734	222.4	1167.0	944.6	867.9	0.3731	1.3236	1.6967
34	257.6	12.24	0.08170	225.9	1168.1	942.2	865.2	0.3781	1.3137	1.6918
36	260.9	11.60	0.08621	229.4	1169.2	939.9	862.7	0.3829	1.3044	1.6873
38	264.2	11.03	0.09066	232.6	1170.3	937.7	860.2	0.3874	1.2956	1.6830
40	267.2	10.51	0.09515	235.8	1171.3	935.5	857.8	0.3917	1.2871	1.6788
42	270.2	10.04	0.09960	238.8	1172.3	933.5	855.5	0.3958	1.2791	1.6749
44	273.0	9.61	0.1040	241.7	1173.2	931.5	853.3	0.3998	1.2714	1.6712
46	275.8	9.22	0.1085	244.5	1174.1	929.6	851.2	0.4036	1.2640	1.6676
48	278.4	8.86	0.1129	247.2	1174.9	927.7	849.1	0.4072	1.2570	1.6642
50	281.0	8.53	0.1173	249.8	1175.7	925.9	847.1	0.4108	1.2501	1.6609
52	283.5	8.22	0.1217	252.3	1176.4	924.1	845.1	0.4142	1.2435	1.6577
54	285.9	7.93	0.1261	254.7	1177.1	922.4	843.2	0.4174	1.2373	1.6547
56	288.2	7.67	0.1304	257.1	1177.8	920.7	841.4	0.4206	1.2311	1.6517
58	290.5	7.42	0.1348	259.5	1178.5	919.0	839.5	0.4237	1.2252	1.6489
60	292.7	7.18	0.1392	261.7	1179.1	917.4	837.8	0.4267	1.2195	1.6462
62	294.9	6.97	0.1435	263.9	1179.7	915.8	836.0	0.4296	1.2139	1.6435
64	296.9	6.76	0.1479	266.1	1180.3	914.2	834.3	0.4324	1.2085	1.6409
66	299.0	6.57	0.1522	268.2	1180.9	912.7	832.7	0.4351	1.2032	1.6384
68	301.0	6.39	0.1566	270.2	1181.4	911.2	831.0	0.4379	1.1981	1.6360
70	302.9	6.22	0.1609	[illegible]	[illegible]	[illegible]	[illegible]	0.4405	1.1931	1.6336
72	304.8	6.05	0.1652	[illegible]	[illegible]	[illegible]	[illegible]	0.4431	1.1882	1.6313
74	306.7	5.90	0.1695	[illegible]	[illegible]	[illegible]	[illegible]	0.4456	1.1835	1.6291
76	308.5	5.75	0.1738	[illegible]	[illegible]	[illegible]	[illegible]	0.4480	1.1789	1.6269
78	310.3	5.61	0.1781	[illegible]	[illegible]	[illegible]	[illegible]	0.4504	1.1744	1.6248
80	312.0	5.48	0.1824	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
82	313.7	5.35	0.1868	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
84	315.4	5.23	0.1911	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
86	317.1	5.12	0.1953	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
88	318.7	5.01	0.1996	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
90	320.3	4.905	0.2039	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
92	321.8	4.805	0.2081	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
94	323.3	4.710	0.2124	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
96	324.8	4.617	0.2166	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
98	326.3	4.528	0.2209	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
100	327.8	4.442	0.2251	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
102	329.2	4.359	0.2294	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
104	330.7	4.279	0.2337	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
106	332.0	4.202	0.2380	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
108	333.4	4.128	0.2422	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
110	334.8	4.057	0.2465	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112	336.1	3.988	0.2508	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
114	337.4	3.921	0.2551	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
116	338.7	3.857	0.2594	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
118	340.0	3.795	0.2635	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

---

[a] This table is abstracted from *Properties of Steam and Ammonia* by Prof. G. A. Goodenough.

TABLE 1. PROPERTIES OF SATURATED STEAM[a] (Continued)

ABSOLUTE PRESSURE, LB. PER SQ. IN.	TEMPERATURE, DEG. FAHR.	VOLUME, CU. FT. PER LB.	WEIGHT, LB. PER CU. FT.	HEAT CONTENT IN B.T.U.		LATENT HEAT IN B.T.U.		ENTROPY		
				of Liquid	of Vapor	of Vaporization	Internal	of Liquid	of Vaporization	of Vapor
p	t	v''	$1/v''$	i'	i''	r	p	s'	r/T	s''
120	341.3	3.735	0.2678	311.9	1191.4	879.5	796.9	0.4911	1.0982	1.5893
122	342.5	3.676	0.2720	313.2	1191.6	878.5	795.8	0.4927	1.0952	1.5879
124	343.7	3.620	0.2762	314.4	1191.9	877.5	794.8	0.4943	1.0922	1.5865
126	345.0	3.566	0.2805	315.7	1192.1	876.4	793.7	0.4958	1.0894	1.5852
128	346.2	3.513	0.2847	316.9	1192.4	875.4	792.6	0.4974	1.0865	1.5838
130	347.4	3,461	0.2889	318.2	1192.6	874.4	791.6	0.4989	1.0836	1.5825
132	348.5	3.412	0.2931	319.4	1192.9	873.5	790.5	0.5004	1.0808	1.5812
134	349.7	3.363	0.2973	320.6	1193.1	872.5	789.5	0.5019	1.0781	1.5800
136	350.8	3.316	0.3016	321.8	1193.3	871.5	788.5	0.5033	1.0754	1.5787
138	352.0	3.270	0.3058	323.0	1193.5	870.5	787.4	0.5048	1.0727	1.5775
140	353.1	3.226	0.3100	324.2	1193.7	869.6	786.4	0.5062	1.0700	1.5762
142	354.2	3.182	0.3142	325.3	1193.9	868.6	785.4	0.5076	1.0674	1.5750
144	355.3	3.140	0.3184	326.5	1194.1	867.7	784.5	0.5090	1.0648	1.5738
146	356.3	3.099	0.3227	327.6	1194.3	866.8	783.5	0.5104	1.0623	1.5727
148	357.4	3.059	0.3269	328.7	1194.5	865.8	782.5	0.5117	1.0598	1.5715
150	358.5	3.020	0.3311	329.8	1194.7	864.9	781.6	0.5131	1.0573	1.5704
152	359.5	2.982	0.3353	330.9	1194.9	864.0	780.6	0.5144	1.0548	1.5692
154	360.5	2.945	0.3396	332.0	1195.1	863.1	779.7	0.5157	1.0524	1.5681
156	361.6	2.909	0.3438	333.1	1195.3	862.3	778.7	0.5170	1.0500	1.5670
158	362.6	2.874	0.3480	334.1	1195.5	861.4	777.8	0.5183	1.0476	1.5659
160	363.6	2.839	0.3522	335.2	1195.7	860.5	776.9	0.5196	1.0453	1.5649
162	364.6	2.806	0.3564	336.2	1195.8	859.6	776.0	0.5209	1.0429	1.5638
164	365.6	2.773	0.3606	337.3	1196.0	858.7	775.1	0.5221	1.0406	1.5627
166	366.5	2.741	0.3648	338.3	1196.2	857.9	774.2	0.5233	1.0384	1.5617
168	367.5	2.710	0.3691	339.3	1196.3	857.0	773.3	0.5245	1.0361	1.5607
170	368.5	2.679	0.3733	340.3	1196.5	856.2	772.4	0.5258	1.0339	1.5597
172	369.4	2.649	0.3775	341.3	1196.6	855.3	771.5	0.5270	1.0317	1.5587
174	370.4	2.620	0.3817	342.3	1196.8	854.5	770.6	0.5281	1.0295	1.5577
176	371.3	2.591	0.3859	343.3	1196.9	853.6	769.8	0.5293	1.0274	1.5567
178	372.2	2.563	0.3901	344.3	1197.1	852.8	768.9	0.5305	1.0252	1.5557
180	373.1	2.536	0.3943	345.2	1197.2	852.0	768.0	0.5316	1.0231	1.5547
182	374.0	2.509	0.3985	346.2	1197.4	851.2	767.2	0.5238	1.0210	1.5538
184	374.9	2.483	0.4027	347.1	1197.5	850.4	766.4	0.5339	1.0189	1.5528
186	375.8	2.457	0.4069	348.1	1197.6	849.5	765.5	0.5350	1.0169	1.5519
188	376.7	2.432	0.4111	349.0	1197.8	848.7	764.7	0.5361	1.0148	1.5509
190	377.6	2.408	0.4154	350.0	1197.9	847.9	763.9	0.5372	1.0128	1.5500
192	378.5	2.383	0.4196	350.9	1198.0	847.1	763.0	0.5383	1.0108	1.5491
194	379.3	2.360	0.4238	351.8	1198.1	846.3	762.2	0.5394	1.0089	1.5482
196	380.2	2.337	0.4280	352.7	1198.2	845.6	761.4	0.5404	1.0069	1.5473
198	381.0	2.314	0.4322	353.6	1198.4	844.8	760.6	0.5415	1.0049	1.5464
200	381.9	2.292	0.4364	354.5	1198.5	844.0	759.8	0.5426	1.0030	1.5456
202	382.7	2.270	0.4406	355.4	1198.6	843.2	759.0	0.5436	1.0011	1.5447
204	383.5	2.248	0.4448	356.2	1198.7	842.5	758.2	0.5446	0.9992	1.5438
206	384.4	2.227	0.4490	357.1	1198.8	841.7	757.4	0.5457	0.9973	1.5430
208	385.2	2.206	0.4532	358.0	1198.9	840.9	756.7	0.5467	0.9954	1.5421
210	386.0	2.186	0.457	358.8	1199.0	840.2	755.9	0.5477	0.9936	1.5413
212	386.8	2.166	0.462	359.7	1199.1	839.4	755.1	0.5487	0.9918	1.5405
214	387.6	2.147	0.466	360.5	1199.2	838.7	754.3	0.5497	0.9900	1.5396
216	388.4	2.128	0.470	361.4	1199.3	837.9	753.6	0.5507	0.9881	1.5388
218	389.2	2.109	0.474	362.2	1199.4	837.2	752.8	0.5516	0.9864	1.5380
220	390.0	2.090	0.478	363.0	1199.5	836.5	752.1	0.5526	0.9846	1.5372

[a] This table is abstracted from *Properties of Steam and Ammonia* by Prof. G. A. Goodenough.

491.6 cu. ft. of gas measured at 32 deg. fahr. is cooled 20 deg. fahr., at constant pressure the new volume will be 471.6 cu. ft.

It is only necessary to add (491.6 − 32) or 459.6 to the actual thermometer reading to get the absolute temperature, that is, $T = t + 459.6$, *where* T = absolute temperature, and t = actual thermometer reading on the Fahrenheit scale. For engineering work 460 deg. is used rather than 459.6 deg. For the Centigrade scale the relation is $T = t + 273.1$.

TABLE 2. VELOCITIES OF DRY AIR (AT VARIOUS TEMPERATURES) CORRESPONDING TO VARIOUS VELOCITY PRESSURES IN OUNCES PER SQUARE INCH[a]

PRESSURE		TEMPERATURE, DEG. FAHR.									
Ounces	Inches	50°	60°	70°	80°	100°	150°	200°	300°	500°	550°
0.1	0.1734	1635	1653	1667	1683	1714	1788	1860	1996	2244	2410
0.2	0.3468	2313	2338	2358	2380	2424	2530	2632	2824	3174	3405
0.3	0.5202	2833	2864	2888	2915	2969	3098	3223	3458	3887	4175
0.4	0.6936	3272	3307	3335	3367	3428	3578	3722	3994	4489	4850
0.5	0.8670	3658	3698	3729	3765	3833	4000	4162	4466	5019	5395
0.6	1.0400	4007	4051	4085	4124	4199	4382	4559	4892	5498	5900
0.7	1.2140	4329	4375	4412	4454	4535	4733	4924	5283	5938	6380
0.8	1.3870	4626	4677	4716	4761	4848	5059	5263	5647	6347	6820
0.9	1.5605	4907	4960	5002	5050	5142	5366	5582	5990	6733	7250
1.0	1.7340	5172	5229	5273	5323	5420	5656	5884	6314	7098	7625
1.1	1.9073	5426	5485	5531	5584	5685	5933	6172	6623	7444	8000
1.2	2.0808	5664	5725	5774	5828	5935	6194	6443	6914	7772	8350
1.3	2.2540	5896	5960	6011	6068	6179	6448	6708	7198	8090	8700
1.4	2.4275	6120	6186	6238	6297	6412	6692	6962	7470	8396	9020
1.5	2.6010	6335	6404	6457	6520	6638	6928	7207	7733	8692	9345
1.6	2.7742	6543	6614	6670	6734	6856	7155	7444	7987	8977	9650
1.8	3.1210	6942	7017	7076	7143	7274	7591	7897	8473	9524	10220
2.0	3.4680	7315	7395	7457	7528	7665	8000	8322	8930	10037	10780
2.2	3.8145	7672	7755	7820	7894	8038	8462	8727	9364	10525	11300
2.4	4.1615	8012	8099	8168	8245	8396	8762	9115	9781	10995	11800
2.6	4.5080	8338	8429	8500	8581	8737	9118	9486	10179	11440	12280
2.8	4.8550	8654	8748	8822	8906	9068	9464	9845	10564	11873	12750
3.0	5.2020	8960	9057	9134	9220	9388	9798	10193	10938	12293	13200

[a] From *Fan Engineering*, published by The Buffalo Forge Company.

TABLE 3. WEIGHTS OF MATERIALS

	Pounds per Cubic Foot		*Pounds per Cubic Foot*
Ashes	45 – 50	Lignite	31 – 47
Barley	37 – 40	Lime	50 – 80
Cement	90 – 118	Limestone	90 – 110
Charcoal	17 – 27	Oats	28 – 31
Clay	95 – 169	Ore	105 – 215
Coal (lump)	50 – 54	Rye	44 – 50
Nut and screenings	53 – 60	Sand	75 – 120
Coke	26 – 30	Slag (blast-furnace)	37 – 63
Earth	75 – 115	Stone	90 – 120
Gravel	90 – 135	Wheat	44 – 50

TABLE 4. LINEAL EXPANSION OF SOLIDS AT ORDINARY TEMPERATURES[a]

(*Tabular values represent increase per foot per 100 deg. increase in temperature, Fahrenheit*)

SUBSTANCE	TEMP. CONDITIONS[b] DEG. FAHR.	COEFFICIENT PER 100 DEG. FAHR.	SUBSTANCE	TEMP. CONDITIONS[b] DEG. FAHR.	COEFFICIENT PER 100 DEG. FAHR.
Brass (cast)	32 to 212	0.001042	Lead	32 to 212	0.001505
Brass (wire)	32 to 212	0.001072	Mercury[c]	32 to 212	0.009984
Copper	32 to 212	0.000926	Limestone	32 to 212	0.000139
Glass (English flint)	32 to 212	0.000451	Steel (Bessemer rolled, hard)	0 to 212	0.00056
Granite (average)	32 to 212	0.000482	Steel (Bessemer rolled, soft)	0 to 212	0.00063
Iron (cast)	104	0.000589	Steel (cast, French)	104	0.000734
Iron (soft forged)	0 to 212	0.000634	Steel (cast annealed, English)	104	0.000608
Iron (wire)	32 to 212	0.000800			

[a] From *Mechanical Equipment of Buildings*, Vol. 1, by Harding and Willard, revised edition, 1929.

[b] Where range of temperature is given, coefficient is mean over range.

[c] Coefficient of cubical expansion.

TABLE 5. PROPERTIES OF SATURATED AIR[a]

Weights of Air, Vapor of Water, and Saturated Mixture of Air and Vapor at Different Temperatures, Under Standard Atmospheric Pressure of 29.921 in. of Mercury

TEMPERATURE, DEG. FAHR.	VAPOR PRESSURE, INCHES OF MERCURY	WEIGHT PER CUBIC FOOT OF MIXTURE			B.T.U. ABSORBED BY 1 CU. FT. SATURATED AIR PER DEG. FAHR.	CUBIC FEET SATURATED AIR WARMED 1 DEG. PER B.T.U.
		Weight of Dry Air, Pound	Weight of Vapor, Pound	Total Weight of Mixture, Pound		
0	0.0383	0.08625	0.000069	0.08632	0.02082	48.04
10	0.0631	0.08433	0.000111	0.08444	0.02039	49.05
20	0.1030	0.08247	0.000177	0.08265	0.01998	50.05
30	0.1640	0.08063	0.000276	0.08091	0.01955	51.15
40	0.2477	0.07880	0.000409	0.07921	0.01921	52.06
50	0.3625	0.07694	0.000587	0.07753	0.01883	53.11
60	0.5220	0.07506	0.000829	0.07589	0.01852	54.00
70	0.7390	0.07310	0.001152	0.07425	0.01811	55.22
80	1.0290	0.07095	0.001576	0.07253	0.01788	55.93
90	1.4170	0.06881	0.002132	0.07094	0.01763	56.72
100	1.9260	0.06637	0.002848	0.06922	0.01737	57.57
110	2.5890	0.06367	0.003763	0.06743	0.01716	58.27
120	3.4380	0.06062	0.004914	0.06553	0.01696	58.96
130	4.5200	0.05716	0.006357	0.06352	0.01681	59.50
140	5.8800	0.05319	0.008140	0.06133	0.01669	59.92
150	7.5700	0.04864	0.010310	0.05894	0.01663	60.14
160	9.6500	0.04341	0.012956	0.05637	0.01664	60.10
170	12.2000	0.03735	0.016140	0.05349	0.01671	59.85
180	15.2900	0.03035	0.019940	0.05029	0.01682	59.45
190	19.0200	0.02227	0.024465	0.04674	0.01706	58.80
200	23.4700	0.01297	0.029780	0.04275	0.01750	57.15

[a]From *Fan Engineering*, published by The Buffalo Forge Company.

TABLE 6. VELOCITIES OF DRY AIR (AT VARIOUS TEMPERATURES) CORRESPONDING TO VARIOUS VELOCITY PRESSURES IN INCHES OF WATER[a]

PRESSURE		TEMPERATURE, DEG. FAHR.									
Inches	Ounces	50°	60°	70°	80°	100°	150°	200°	300°	500°	550°
0.1	0.0577	1242	1255	1266	1278	1300	1358	1413	1516	1704	1830
0.2	0.1154	1757	1776	1791	1808	1841	1921	2000	2145	2411	2590
0.25	0.1443	1965	1986	2003	2022	2059	2149	2235	2399	2696	2895
0.3	0.1730	2151	2175	2193	2214	2254	2352	2447	2626	2952	3175
0.4	0.2308	2485	2512	2533	2557	2603	2717	2827	3033	3409	3660
0.5	0.2884	2778	2808	2832	2859	2911	3038	3160	3391	3812	4095
0.6	0.3460	3043	3076	3102	3131	3188	3327	3462	3715	4175	4490
0.7	0.4037	3287	3323	3351	3383	3445	3595	3740	4013	4510	4850
0.75	0.4326	3402	3439	3468	3501	3565	3720	3870	4153	4668	5020
0.8	0.4614	3524	3552	3582	3616	3682	3843	3997	4290	4821	5185
0.9	0.5190	3728	3768	3800	3836	3906	4076	4241	4550	5114	5500
1.0	0.5768	3929	3971	4005	4043	4117	4296	4470	4796	5390	5795
1.25	0.7209	4393	4440	4478	4520	4602	4804	4997	5362	6027	6470
1.50	0.8650	4812	4864	4905	4952	5042	5262	5474	5874	6602	7100
1.75	1.0092	5197	5254	5298	5348	5446	5683	5912	6344	7131	7655
2.00	1.1535	5556	5616	5664	5718	5822	6076	6320	6783	7624	8195
2.25	1.2975	5892	5956	6007	6064	6174	6443	6704	7193	8085	8690
2.50	1.4418	6211	6278	6332	6392	6508	6792	7066	7582	8523	9150
2.75	1.5860	6514	6585	6641	6704	6827	7124	7412	7952	8938	9600
3.00	1.7300	6807	6879	6937	7003	7130	7440	7742	8307	9336	10000
4.00	2.3070	7857	7942	8010	8086	8233	8592	8940	9581	10780	11580
5.00	2.8840	8772	8867	8943	9027	9192	9593	9980	10710	12037	12900
6.00	3.4600	9623	9728	9810	9903	10083	10523	10950	11750	13203	14180

[a]From *Fan Engineering*, published by The Buffalo Forge Company.

TABLE 7. CIRCUMFERENCES AND AREAS OF CIRCLES

DIAMETER IN INCHES	AREA		CIRCUMFERENCE		DIAMETER IN INCHES	AREA		CIRCUMFERENCE	
	Sq. In.	Sq. Ft.	Inches	Feet		Sq. In.	Sq. Ft.	Inches	Feet
¼	0.049	0.0003	0.785	0.0652	28	615.8	4.276	87.97	7.330
½	0.196	0.0014	1.571	0.1309	28½	637.9	4.430	89.54	7.462
¾	0.442	0.0031	2.356	0.1964	29	660.52	4.587	91.11	7.592
1	0.785	0.0054	3.142	0.2618	29½	683.5	4.747	92.63	7.725
1¼	1.227	0.0085	3.927	0.3273	30	706.8	4.909	94.25	7.854
1½	1.767	0.0123	4.712	0.3927	31	754.8	5.241	97.39	8.116
1¾	2.405	0.0167	5.498	0.4582	32	804.3	5.585	100.5	8.378
2	3.142	0.0218	6.283	0.5236	33	855.3	5.940	103.7	8.639
2¼	3.976	0.0276	7.069	0.5891	34	907.9	6.305	106.8	8.901
2½	4.909	0.0341	7.854	0.6546	35	962.1	6.681	109.9	9.163
2¾	5.939	0.0412	8.639	0.7200	36	1018.0	7.069	113.1	9.425
3	7.069	0.0491	9.425	0.7854	37	1075.0	7.467	116.2	9.686
3¼	8.296	0.0576	10.21	0.8510	38	1134.0	7.876	119.4	9.948
3½	9.621	0.0668	10.99	0.9160	39	1195.0	8.296	122.5	10.21
3¾	11.04	0.0767	11.78	0.9818	40	1256.0	8.727	125.6	10.47
4	12.57	0.0873	12.57	1.047	41	1320.0	9.168	128.8	10.73
4¼	14.19	0.0986	13.35	1.113	42	1385.0	9.621	131.9	10.99
4½	15.90	0.1104	14.14	1.178	43	1452.0	10.08	135.1	11.26
4¾	17.72	0.1231	14.92	1.243	44	1521.0	10.56	138.2	11.52
5	19.64	0.1364	15.71	1.309	45	1590.0	11.04	141.4	11.78
5¼	21.65	0.1504	16.49	1.374	46	1662.0	11.54	144.5	12.04
5½	23.76	0.1650	17.28	1.440	47	1735.0	12.05	147.7	12.30
5¾	25.97	0.1840	18.06	1.505	48	1810.0	12.51	150.8	12.57
6	28.27	0.1964	18.85	1.571	49	1886.0	13.09	153.9	12.83
6¼	30.68	0.2131	19.64	1.637	50	1963.0	13.64	157.1	13.09
6½	33.18	0.2304	20.42	1.702	51	2043.0	14.19	160.2	13.35
6¾	35.79	0.2486	21.21	1.768	52	2124.0	14.75	163.4	13.61
7	38.49	0.2673	21.99	1.833	53	2206.0	15.32	166.5	13.88
7¼	41.28	0.2867	22.78	1.899	54	2290.0	15.90	169.6	14.14
7½	44.18	0.3068	23.56	1.964	55	2376.0	16.50	172.8	14.40
7¾	47.17	0.3276	24.35	2.029	56	2463.0	17.10	175.9	14.66
8	50.27	0.3491	25.13	2.094	57	2552.0	17.72	179.1	14.92
8¼	53.46	0.3713	25.92	2.160	58	2642.0	18.35	182.2	15.18
8½	56.75	0.3942	26.70	2.225	59	2734.0	18.99	185.4	15.45
8¾	60.13	0.4175	27.49	2.291	60	2827.0	19.63	188.5	15.71
9	63.62	0.4418	28.27	2.356	61	2922.0	20.29	191.6	15.97
9¼	67.20	0.4668	29.06	2.422	62	3019.0	20.97	194.8	16.23
9½	70.88	0.4923	29.85	2.488	63	3117.0	21.65	197.9	16.49
9¾	74.66	0.5185	30.63	2.553	64	3217.0	22.34	201.1	16.76
10	78.54	0.5454	31.42	2.618	65	3318.0	23.04	204.2	17.02
10½	86.59	0.6010	32.99	2.750	66	3421.0	23.76	207.3	17.28
11	95.03	0.6600	34.56	2.880	67	3526.0	24.48	210.5	17.54
11½	103.9	0.7215	36.13	3.011	68	3632.0	25.22	213.6	17.80
12	113.1	0.7854	37.70	3.142	69	3739.0	25.97	216.8	18.06
12½	122.7	0.8520	39.27	3.273	70	3848.0	26.73	219.9	18.33
13	132.7	0.9218	40.84	3.403	71	3959.0	27.49	223.1	18.59
13½	143.1	0.9937	42.41	3.535	72	4072.0	28.27	226.2	18.85
14	153.9	1.069	43.98	3.665	73	4185.0	29.07	229.3	19.11
14½	165.1	1.146	45.55	3.796	74	4301.0	29.87	232.5	19.37
15	176.7	1.227	47.12	3.927	75	4418.0	30.68	235.6	19.63
15½	188.7	1.310	48.69	4.058	76	4536.0	31.50	238.8	19.90
16	201.1	1.396	50.27	4.189	77	4657.0	32.34	241.9	20.16
16½	213.8	1.485	51.84	4.321	78	4778.0	33.18	245.0	20.42
17	226.9	1.576	53.41	4.451	79	4902.0	34.04	248.2	20.68
17½	240.5	1.670	54.98	4.582	80	5027.0	34.91	251.3	20.94
18	254.5	1.767	56.55	4.712	81	5153.0	35.78	254.5	21.21
18½	268.8	1.867	58.12	4.845	82	5281.0	36.67	257.6	21.47
19	283.5	1.969	59.69	4.974	83	5411.0	37.57	260.8	21.73
19½	298.6	2.074	61.26	5.105	84	5542.0	38.48	263.9	21.99
20	314.2	2.182	62.83	5.236	85	5675.0	39.41	267.0	22.25
20½	330.1	2.293	64.40	5.367	86	5809.0	40.34	270.2	22.51
21	346.4	2.405	65.97	5.498	87	5945.0	41.28	273.3	22.78
21½	361.1	2.508	67.54	5.629	88	6082.0	42.24	276.5	23.04
22	380.1	2.640	69.12	5.760	89	6221.0	43.20	279.6	23.30
22½	397.6	2.761	70.69	5.891	90	6362.0	44.18	282.7	23.56
23	415.5	2.885	72.26	6.021	91	6504.0	45.17	285.9	23.82
23½	433.7	3.012	73.83	6.153	92	6648.0	46.16	289.0	24.09
24	452.4	3.142	75.40	6.283	93	6793.0	47.17	292.2	24.35
24½	471.4	3.274	76.97	6.415	94	6940.0	48.19	295.3	24.61
25	490.9	3.409	78.54	6.545	95	7088.0	49.22	298.4	24.87
25½	510.7	3.547	80.11	6.676	96	7238.0	50.27	301.6	25.13
26	530.9	3.687	81.68	6.807	97	7390.0	51.32	304.7	25.39
26½	551.6	3.832	83.25	6.938	98	7543.0	52.38	307.9	25.66
27	572.6	3.976	84.82	7.069	99	7698.0	53.46	311.0	25.92
27½	593.9	4.125	86.39	7.199	100	7854.0	54.54	314.2	26.18

TABLE 8. PROPERTIES OF DRY AIR[a]

Barometric Pressure 29.921 In.

TEMPERATURE, DEG. FAHR.	WEIGHT PER CUBIC FOOT, POUND	RATIO OF VOLUME TO VOLUME AT 70 DEG. FAHR.	B.T.U. ABSORBED BY 1 CU. FT. DRY AIR PER DEG. FAHR.	CUBIC FEET DRY AIR WARMED 1 DEG. PER B.T.U.
−50	0.09690	0.7735	0.02335	42.82
−45	0.09573	0.7829	0.02307	43.34
−40	0.09459	0.7924	0.02280	43.87
−35	0.09348	0.8018	0.02253	44.39
−30	0.09239	0.8112	0.02226	44.91
−25	0.09133	0.8206	0.02201	45.43
−20	0.09029	0.8301	0.02176	45.96
−15	0.08927	0.8396	0.02151	46.48
−10	0.08828	0.8490	0.02127	47.00
− 5	0.08731	0.8585	0.02104	47.52
0	0.08636	0.8680	0.02080	48.08
5	0.08544	0.8772	0.02060	48.55
10	0.08453	0.8867	0.02039	49.05
15	0.08363	0.8962	0.02018	49.56
20	0.08276	0.9057	0.01998	50.05
25	0.08190	0.9152	0.01977	50.58
30	0.08107	0.9246	0.01957	51.10
35	0.08025	0.9340	0.01938	51.60
40	0.07945	0.9434	0.01919	52.11
45	0.07866	0.9530	0.01900	52.64
50	0.07788	0.9624	0.01881	53.17
55	0.07713	0.9718	0.01863	53.68
60	0.07640	0.9811	0.01846	54.18
65	0.07567	0.9905	0.01829	54.68
70	0.07495	1.0000	0.01812	55.19
75	0.07424	1.0095	0.01795	55.72
80	0.07356	1.0190	0.01779	56.21
85	0.07289	1.0283	0.01763	56.72
90	0.07222	1.0380	0.01747	57.25
95	0.07157	1.0472	0.01732	57.74
100	0.07093	1.0570	0.01716	58.28
105	0.07030	1.0660	0.01702	58.76
110	0.06968	1.0756	0.01687	59.28
115	0.06908	1.0850	0.01673	59.78
120	0.06848	1.0945	0.01659	60.28
125	0.06790	1.1040	0.01645	60.79
130	0.06732	1.1133	0.01631	61.32
135	0.06675	1.1230	0.01618	61.81
140	0.06620	1.1320	0.01605	62.31
145	0.06565	1.1417	0.01592	62.82
150	0.06510	1.1512	0.01578	63.37
160	0.06406	1.1700	0.01554	64.35
170	0.06304	1.1890	0.01530	65.36
180	0.06205	1.2080	0.01506	66.40
190	0.06110	1.2270	0.01484	67.40
200	0.06018	1.2455	0.01462	68.41
220	0.05840	1.2833	0.01419	70.48
240	0.05673	1.3212	0.01380	72.46
260	0.05516	1.3590	0.01343	74.46
280	0.05367	1.3967	0.01308	76.46
300	0.05225	1.4345	0.01274	78.50
350	0.04903	1.5288	0.01197	83.55
400	0.04618	1.6230	0.01130	88.50
450	0.04364	1.7175	0.01070	93.46
500	0.04138	1.8113	0.01018	98.24
550	0.03932	1.9060	0.00967	103.42
600	0.03746	2.0010	0.00923	108.35
700	0.03423	2.1900	0.00847	118.07
800	0.03151	2.3785	0.00782	127.88
900	0.02920	2.5670	0.00728	137.37
1000	0.02720	2.7560	0.00680	147.07
1200	0.02392	3.1335	0.00603	165.83

---

[a] From *Mechanical Equipment of Buildings*, Vol. 1, by Harding and Willard, second edition, 1929.

TABLE 9. SPECIFIC HEAT OF VARIOUS SOLIDS AND LIQUIDS BETWEEN 32 AND 212 DEG. FAHR.[a]

SOLIDS	
Alloys:	
Bismuth-tin	0.040–0.045
Bell metal	0.086
Brass, yellow	0.0883
Brass, red	0.090
Bronze	0.104
Constantan	0.098
D'Arcet's metal	0.050
German silver	0.095
Lipowitz's metal	0.040
Nickel steel	0.109
Rose's metal	0.050
Solders (Pb and Sn)	0.040–0.045
Type metal	0.0388
Wood's metal	0.040
40 Pb + 60 Bi	0.0317
25 Pb + 75 Bi	0.030
Asbestos	0.20
Ashes	0.20
Basalt (lava)	0.20
Borax	0.229
Brick	0.22
Carbon-coke	0.203
Chalk	0.215
Charcoal	0.20
Cinders	0.18
Coal	0.314
Concrete	0.27
Cork	0.485
Corundum	0.198
Dolomite	0.222
Ebonite	0.33
SOLIDS	
Glass:	
Normal	0.199
Crown	0.16
Flint	0.12
Gneiss	0.18
Granite	0.195
Graphite	0.201
Gypsum	0.259
Hornblende	0.195
Humus (soil)	0.44
Ice	0.504
India rubber (Para)	0.27–0.48
Kaolin	0.224
Limestone	0.217
Marble	0.210
Oxides:	
Alumina (Al_2O_3)	0.183
Cu_2O	0.111
Lead oxide (PbO)	0.055
Lodestone	0.156
Magnesia	0.222
Magnetite (Fe_3O_4)	0.168
Silica	0.191
Soda	0.231
Zinc oxide (ZnO)	0.125
Paraffin wax	0.69
Porcelain	0.255
Quartz	0.17–0.28
Quicklime	0.217
Salt, rock	0.21
Sand	0.195
Sandstone	0.22
Serpentine	0.25
Sulphur	0.180
Talc	0.209
SOLIDS	
Tufa	0.33
Vulcanite	0.331
Wood:	
Fir	0.65
Oak	0.57
Pine	0.67
LIQUIDS	
Acetic acid	0.51
Alcohol (absolute)	0.70
Aniline	0.514
Benzol	0.43
Chloroform	0.23
Ether	0.503
Fusel oil	0.56
Gasoline	0.70
Glycerine	0.576
Hydrochloric acid	0.60
Kerosene	0.50
Naphthalene	0.31
Machine oil	0.40
Mercury	0.033
Olive oil	0.35
Paraffin oil	0.52
Petroleum	0.498
Sulphuric acid	0.336
Sea water	0.94
Toluene	0.40
Turpentine	0.472
Molten metals:	
Bismuth (535–725 deg. fahr)	0.036
Lead (590–680 deg. fahr.)	0.041
Sulphur (246–297 deg. fahr.)	0.235
Tin (460–660 deg. fahr.)	0.058

[a] From Marks' *Mechanical Engineers' Handbook.*

TABLE 10. METRIC UNITS

1 cm. = 0.3937 in.
1 in. = 2.54 cm.
1 meter = 3.281 ft.
1 ft. = 0.3048 meters
1 sq. cm. = 0.155 sq. in.
1 sq. in. = 6.45 sq. cm.
1 sq. meter = 10.765 sq. ft.
1 sq. ft. = 0.0929 sq. meter

1 cu. cm. = 0.061 cu. in.
1 cu. in. = 16.38 cu. cm.
1 cu. meter = 35.32 cu. ft.
1 cu. ft. = 0.0283 cu. meter
1 liter = 1000 cu. cm. = 0.264 gal.
1 kilogram = 2.2046 lb.
1 lb. = 0.4536 kilograms
1 met. ton = 2205 lb. (avoir.)
1 gram = 980.59 dynes

1 kilometer per hour = 0.6214 mile per hour.
1 gram per square centimeter = 0.2896 in. mercury (at 0 deg. cent.) = 0.394 in. water (at 15 deg. cent.)
1 kg. per square centimeter (metric atmosphere) = 14.22 lb. per square inch
1 gram per cubic centimeter = 0.03613 lb. per cubic inch = 62.43 lb. per cubic foot
1 dyne = 0.00007233 poundals
1 joule = 10,000,000 ergs = 0.73767 ft. lb.
1 metric hp. (force de cheval) = 75 kg.-meters per second = 0.986 hp. (U. S.)
1 kilogram-calorie (large calorie) = 1,000 gram-calories (small calorie)
1 kilogram-calorie = 3.97 B.t.u.
1 kg. calorie per kilogram = 1.8 B.t.u. per pound
1 gram-calorie per square centimeter = 3.687 B.t.u. per sq. ft.
1 gram-calorie per square centimeter per centimeter = 1.451 B.t.u. per square foot per inch
1 gram-calorie per second per square centimeter for a temperature graduation of 1 deg. cent. per centimeter of thickness. = 2,903 B.t.u. per hour per square foot for a temperature graduation of 1 deg. fahr. per inch of thickness.

TABLE 11. DENSITY OF LIQUIDS (WATER = 1)

Alcohol	0.789
Draft gage oil (ellison)	0.834
Gasoline	0.66–0.67
Hydrochloric acid	1.20
Kerosene	0.75–0.86
Nitric acid	1.50
Sulphuric acid	1.80
Oils (mineral lubricants)	0.90 –0.93
Turpentine	0.861–0.867
Water, 39.1 deg. fahr.	1.000
Water 212 deg. fahr.	0.958
Water (ice)	0.88 –0.92
Water (fresh fallen snow)	0.125
Water (sea)	1.02 –1.93

TABLE 12. PROPERTIES OF GASES[a]

GAS	CHEMICAL SYMBOL	NUMBER OF ATOMS	MOLECULAR WEIGHT		WEIGHT IN POUND OF 1 CU. FT. AT ATMOSPHERIC PRESSURE		DENSITY RELATIVE TO AIR	GAS CONSTANT, *R*	SPECIFIC HEAT PER POUND		SPECIFIC HEAT PER CUBIC FOOT AT ATMOSPHERIC PRESSURE AND 62 DEG. FAHR.		$k=\frac{c_p}{c_v}$
			Approximate	Exact $O_2=32$	At 62 deg. fahr.	At 32 deg. fahr.			c_v	c_p	c_p	c_v	
Helium	He	1	4.0	4.0	0.0105	0.0112	0.137	386.0	1.25	0.75	0.0131	0.0079	1.66
Argon	Ar	1	40.0	39.9	0.1048	0.1112	1.378	38.70	0.124	0.075	0.0131	0.0079	1.66
Air	....	....	29.0	28.95	0.0761	0.0807	**1**	53.34	0.241	0.171	0.0183	0.0130	1.40
Oxygen	O_2	2	32.0	**32**	0.0840	0.0892	1.105	48.25	0.217	0.155	0.0182	0.0130	1.40
Nitrogen	N_2	2	28.0	28.08	0.0737	0.0783	0.970	54.99	0.247	0.176	0.0182	0.0130	1.40
Hydrogen	H_2	2	2.0	2.016	0.00529	0.00562	0.0696	765.86	3.42	2.44	0.0181	0.0129	1.40
Nitric oxide	NO	2	30.0	30.04	0.0789	0.0838	1.038	51.40	0.231	0.165	0.0183	0.0130	1.40
Carbon monoxide	CO	2	28.0	28.00	0.0734	0.0780	0.968	55.14	0.243	0.172	0.0180	0.0126	1.41
Hydrochloric acid	HCl	2	36.5	36.45	0.0958	0.1017	1.260	42.35	0.191	0.136	0.0183	0.0130	1.40
Carbon dioxide	CO_2	3	44.0	44.00	0.1156	0.1227	1.520	35.09	0.210	0.160	0.0243	0.0185	1.31
Nitrous oxide	N_2O	3	44.0	44.08	0.1157	0.1229	1.522	35.03	0.221	0.171	0.0256	0.0198	1.26
Sulphur dioxide	SO_2	3	64.0	64.06	0.1684	0.1786	2.213	24.10	0.154	0.123	0.0260	0.0207	1.25
Ammonia	NH_3	4	17.0	17.06	0.04483	0.0476	0.590	90.50	0.523	0.399	0.0234	0.0178	1.31
Acetylene	C_2H_2	4	26.0	26.02	0.0684	0.0725	0.899	59.34	0.350	0.270	0.024	0.0185	1.28
Methyl chloride	CH_3Cl	5	50.5	50.47	0.1326	0.1407	1.744	30.59	0.24	0.20	0.032	0.0265	1.20
Methane	CH_4	5	16 0	16.03	0.0421	0.0447	0.554	96.31	0.593	0.450	0.025	0.019	1.32
Ethylene	C_2H_4	6	28.0	28.03	0.0738	0.0780	0.969	55.08	0.40	0.33	0.029	0.024	1.20

[a] From Marks' *Mechanical Engineers' Handbook.*

CHAPTER 34

SYMBOLS AND ABBREVIATIONS

Symbols for Heat, Thermodynamics and Hydraulics; Abbreviations; Drafting Room Practice.

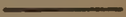
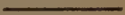
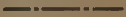
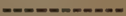
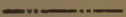
IN this chapter there will be found the symbols for drawings adopted by the A. S. H. V. E. in its CODE OF MINIMUM REQUIREMENTS FOR THE HEATING AND VENTILATION OF BUILDINGS as well as *A. S. A.*[1] *tentative* standard symbols and abbreviations for scientific and engineering terms, also some recommended standards for drafting room practice.

The following distinction between symbols and abbreviations is made: A symbol is a letter or sign used in a formula as a substitute for any numerical value. A shortened expression for a name or a unit is an abbreviation and not a symbol.

SYMBOLS FOR HEATING AND VENTILATING DRAWINGS[2]

1. The objects of this standard set of symbols are to insure the correct interpretation of drawings and to conserve drafting room time by establishing simple and unmistakable symbols for the component parts of the heating and ventilating systems. In preparing the list of symbols an effort has been made to follow existing practice in so far as possible but the list cannot be expected to match exactly the existing practice of every drafting room.

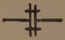
2. Simplicity, ease of execution and unmistakable identification were carefully considered in selecting the symbols. Uncommon fittings and appliances such as vacuum pumps, separators, etc., have purposely been omitted in order to produce a list which can be easily remembered. It is assumed that when the scale of the drawing permits, the valves and fittings will be drawn to scale and a conventional representation is then unnecessary.

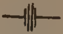
3. High pressure steam supply pipe	
4. Low pressure steam supply pipe	
5. Hot water pipe—flow	
6. Return pipe—steam or water	
7. Air vent line	

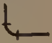
---

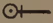
[1] The compilation of these standards is under the supervision of the *American Standards Association*, and the sponsor organizations include: *American Association for the Advancement of Science; American Institute of Electrical Engineers; American Society of Civil Engineers; Society for the Promotion of Engineering Education, and American Society of Mechanical Engineers.*

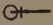
[2] From A. S. H. V. E. CODE OF MINIMUM REQUIREMENTS FOR THE HEATING AND VENTILATION OF BUILDINGS.

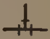
8. Flanges


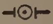
9. Screwed union


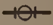
10. Elbow


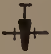
11. Elbow—looking up


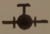
12. Elbow—looking down


13. Tee


14. Tee—looking up


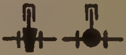
15. Tee—looking down


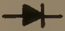
16. Gate valve


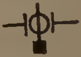
17. Globe valve


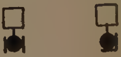
18. Angle valve

19. Angle valve—stem perpendicular

20. Lock shield valve


21. Check valve


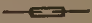
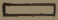
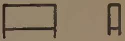
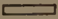
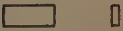
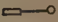
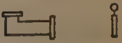
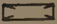
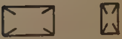
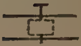
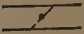
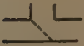
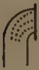
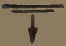
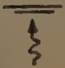
22. Reducing valve


23. Diaphragm valve


24. Diaphragm valve—stem perpendicular

25. Thermostat

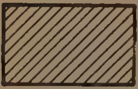
26. Radiator trap—elevation

27. Radiator trap—plan	
28. Expansion joint	
29. Column radiator—plan	
30. Column radiator—elevation	
31. Wall radiator—plan	
32. Wall radiator—elevation	
33. Pipe coil—plan	
34. Pipe coil—elevation	
35. Indirect radiator—plan	
36. Indirect radiator—elevation	
37. Supply duct—section	
38. Exhaust duct—section	
39. Butterfly damper—plan (or elevation)	
40. Butterfly damper—elevation (or plan)	
41. Deflecting damper—square pipe	
42. Vanes	
43. Air supply outlet	
44. Exhaust outlet	

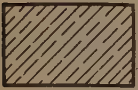
SYMBOLS AND CROSS-SECTIONS FOR MATERIALS

These symbols and cross-sections give a conventional method of distinguishing various materials commonly used, but can only indicate the general character and not complete specification of the material of the parts. They permit of sub-division if found desirable, by making minor changes but maintaining the general characteristics.

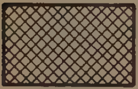
For simplicity on details where the material is named, sections may be shaded or made as for iron or steel.



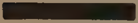
Iron or steel.



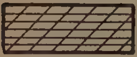
Bronze, brass, copper and compositions.



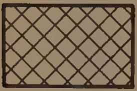
White metal.
Aluminum, zinc, lead, babbitt and alloys.



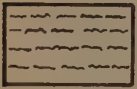
Electric insulation.



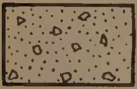
Vulcanite, fibre, mica, Bakelite, etc.



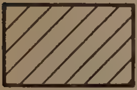
Sound or heat insulation.
Cork, hair-felt, wool, asbestos, magnesia, etc.



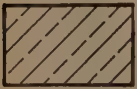
Flexible material.
Fabric, felt, rubber, etc.



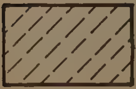
Concrete.



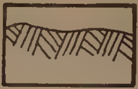
Brick or stone masonry.



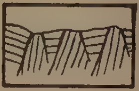
Fire-brick and refractory material.



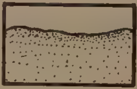
Marble, slate, glass, porcelain, etc.



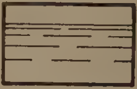
Earth.



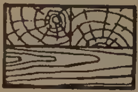
Rock.



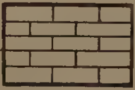
Sand.



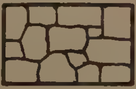
Water and other liquids.



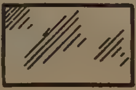
Across grain
With grain
Wood[3]



Brick.[4]



Stone.[4]



Transparent material.[4]
Glass, celluloid, etc.

[3] The symbols for wood may be used for sections and outside views.

[4] Used for outside views but not for sections.

SYMBOLS FOR HEAT AND THERMODYNAMICS[5]

General Principles

1. It is urged that a complete table of symbols and units used by an author be included at a convenient place in each book, chapter, or paper.

2. In most cases the same symbol shall be used, regardless of systems of units. Thus v is specific volume, whether cc per gram, cc per mol, cu ft per lb, etc.

3. In cases where more than one system of units is used in a discussion, a single symbol may be used, with addition of subscripts, superscripts, or indices to denote units other than the primary one, such as, p, p_t, p', p''.

4. The same symbol should be used for a given concept, regardless of the number of special values which occur, and subscripts or superscripts should be used to designate them.

5. Letter subscripts should be used to denote values under special conditions or at special states, such as:

Specific heat at constant pressure	c_p
Specific heat at constant volume	c_v
Thermal efficiency	e_t
Mechanical efficiency	e_m

6. Numerical subscripts should be used to denote values at designated points in an apparatus, process or cycle, such as:

Initial pressure	p_1
Final pressure	p_2
Weight of a major item	W
Weights of auxiliary items	W_1, W_2, W_3

7. In order to increase the clarity of printed matter, which is practically always Roman, symbols alone or in equations should be printed in Italics.

8. Where possible, capital letters denote total quantities and small letters denote specific quantities, or quantities per unit. Thus,

S may be entropy of any mass, and
s may be entropy of unit mass.

General Symbols

Acceleration due to gravity. Internationally adopted standard value 980.665 cm/sec² or 32.1740 ft/sec.²	g_0
Acceleration due to gravity. Where it is not necessary to distinguish between the standard value and the exact local value	g
Time	t
Angular Velocity	ω (omega)
Velocity	V
Revolutions per Unit Time N or	n
Length, Distance	L
Diameter	D
Radius	r
Area, Surface	A

Symbols for Force, Weight, Work, Power

Force, Total Load	F
Pressure; Absolute Pressure; Gage Pressure; Force per Unit Area	p
Mean Effective Pressure	p_m
Total Quantity of Fluid, Water, Gas, Heat; Quantity by Volume	Q
Volume Rate per Unit Time; Rate at which Quantity of Material passes through a Machine; Quantity of Heat per Unit Time; Quantity of Heat per Unit Weight	q
Total Weight	W
Weight Rate; Weight per unit of Power; Weight per unit of Time	w
Mass, W/g	m
Total Work	W
Work per Unit Weight	w
Power; Work per Unit Time	P
Efficiency e or	η (eta)

Symbols for Properties

Molecular Weight	M
Concentration; Amount of Particular Constituent per given amount of Mixture	C

---

[5] Proposed symbols prepared by Sectional Committee on Scientific and Engineering Symbols and Abbreviations.

Specific Gravity, referred to Air for Gases, and Water for Solids or Liquids	G
Specific Volume; Volume per Unit Weight	v
Density; Weight per Unit Volume; Mass per Unit Volume d or $\rho = 1/v$	ρ (rho)
Specific Heat	c
Specific Heat at Constant Pressure	c_p
Specific Heat at Constant Volume	c_v
Ratio of Specific Heats $k = c_p/c_v$	k
Absolute Viscosity; Coefficient of Viscosity, usually in poises or similar units of stress/shear rate	μ (mu)
Relative Viscosity; Ratio of Absolute Viscosity of any fluid to Absolute Viscosity of Water. (If the second option is used, the context must make clear that Relative Viscosity is meant) μ/μ_w or	μ (mu)
Kinematic Viscosity (Absolute Viscosity divided by Density)	ν (nu)
Relative Kinematic Viscosity (Relative Viscosity divided by Density). (If the second option is used the context must make clear that Relative Kinematic Viscosity is meant) ν/ν_w or	ν (nu)
Time in seconds obtained from a viscosity measurement with a specific instrument, from which μ or ν may be computed by appropriate formulas	t

Symbols for Thermodynamics

Mechanical Equivalent of Heat	J
Heat Equivalent of Work $1/J$ or	A
Thermometric Temperature, F or C (θ is preferably used only when t is used for Time in the same discussion) t or	θ (theta)
Absolute Temperature, F abs or K	T
Entropy. (Preferably, the capitals are used for any weight, and small letters, for unit weight) S or	s
Internal Energy; Intrinsic Energy. Preferably, the capital is used for any weight and the small letter for unit weight; U or	u
Heat Content; Total Heat; Enthalpy. Preferably the capital is used for any weight and the small letter for unit weight; H or H or $h = u + (A)\ pv$	h
Helmholtz Free Energy; Internal Potential Function $\psi = u - Ts$	ψ (psi)
Gibbs Function; Total Potential Function Z or $Z = u + (A)\ pv - Ts$	ζ (Zeta)
Saturated Liquid at saturation pressure and temperature; Liquid in contact with Vapor	Sub$_f$
Dry Saturated Vapor; Dry Saturated Gas at saturation pressure and temperature; Vapor in contact with Liquid	Sub$_g$

This system, carried to a logical conclusion, requires also subscripts for Liquid in contact with Solid, Solid in contact with Vapor and Vapor in contact with Solid. However, these subscripts are not assigned at this time. Pairs of subscripts would also denote values for fusion or melting and sublimation.

Conditions at Critical Point	Sub$_c$
Vaporization Values at Constant Pressure; Differences between Values for Saturated Vapor and Saturated Liquid at the same pressure	Sub$_{fg}$
Heat Content of Saturated Liquid; Total Heat of Saturated Liquid; Enthalpy of Saturated Liquid, sometimes called Heat of the Liquid	h_f
Heat Content of Dry Saturated Vapor; Total Heat of Dry Saturated Vapor; Enthalpy of Dry Saturated Vapor	h_g
Various Values for Saturation; Various Values for Vaporization, according to above rules v_f, v_g,	v_{fg}, etc.
Saturation Pressure; Saturation Temperature p_f and	T_f or p_g and T_g
Heat of Vaporization at Constant pressure L or	h_{fg}
Heat of Fusion; Heat of Sublimation, may be denoted by subscripts affixed to the symbols L or h.	
Gas Constant in equation $pv = RT$	R

Two values are in customary use. The first is the universal constant, corresponding to v in the above equation as volume per mol (product of molecular weight and volume per unit weight). The second is the particular value for a given gas, corresponding to v as volume per unit weight. The second

value is the first value divided by molecular weight M. If desired, a prime or a subscript may be used to distinguish between the two values.	
Quality of Steam, pounds of dry steam per pound of mixture	x
Exponent of Polytropic expansion in expression, pv^n = const.	n
Joule-Thomson coefficient, $\mu = (dT/dp)_h$	μ (mu)
Adiabatic Factor	Y

$$Y = \left(\frac{p_1}{p_2}\right)^{(k-1)/k} - 1$$

Symbols for Heat Transmission[6]

Terms ending "ivity" designate properties independent of size or shape, sometimes called "specific properties." Examples are—conductivity and resistivity.

Terms ending "ance" designate quantities depending not only on the material, but also upon size and shape, sometimes called "total quantities." Examples are—conductance and transmittance.

Terms ending "ion" designate rate of heat transfer. Examples are—conduction and transmission.

Area	A
Temperature, F or C	t
Temperature, F abs or K	T
Length of path of heat flow, thickness	L
Total Quantity of Heat Transferred	Q
Thermal Transmission (heat transferred per unit time)	q

$$q = Q/\text{time}$$

Thermal Conductivity (heat transferred per unit time per unit area, and per degree per unit length)	k

$$k = \frac{q/A}{(t_1 - t_2)/L}$$

Thermal Resistivity	$1/k$
Thermal Resistance (degrees, per unit of heat transferred per unit time per unit area	R

$$R = \frac{t_1 - t_2}{q/A}$$

Thermal Conductance (heat transferred per unit time per unit area, per degree)	C

$$C = \frac{1}{R} = \frac{k}{L} = \frac{q/A}{t_1 - t_2}$$

Film Conductance (heat transferred per unit time per unit area, per degree)	f

$$f = \frac{q/A}{t_1 - t_2}$$

Film Resistance (degrees per unit of heat transferred per unit time per unit area)	$1/f$

$$\frac{1}{f} = \frac{t_1 - t_2}{q/A}$$

Thermal Transmittance, or Coefficient of Heat Transfer (heat transferred per unit time per unit area, per degree)	U

$$U = \frac{q/A}{t_1 - t_2}$$

ABBREVIATIONS FOR ENGINEERING AND SCIENTIFIC TERMS[7]

Fundamental Rules for Formation and Use

Abbreviations should be used sparingly in text and with regard to the context and to the training of the reader. Terms denoting units of measure are abbreviated in the text only when preceded by the amounts indicated in numerals; thus "several inches," "one inch," "12 in." In tablular matter, specifications, maps, drawings, and texts for special purposes, the use of abbreviations is governed by the desirability of conserving space.

Do not begin a sentence with a numeral followed by an abbreviation.

Avoid capitals in abbreviations except in words normally capitalized.

Hyphenated compound words call for hyphenated abbreviations; thus "hp-hr."

With but few exceptions of abbreviations in common usage, the singular only is used; thus "in." for "inches," not "ins."; but No., Nos., Fig., Figs.

---

[6] Joint report of the Committee on Heat Transmission, *National Research Council* and Sub-committee on Symbols for Heat and Thermodynamics, *American Standards Association.*

[7] Proposed Standard prepared by Sectional Committee on Scientific and Engineering Symbols and Abbreviations.

Short words such as ton, day, and mile are spelled out.

Do not use abbreviations where the meaning will not be clear. In case of doubt, spell out.

Do not use conventional signs for abbreviations in text; thus per, not /; lb., not #; in., not ″. Such signs are used sparingly in tables and similar places for conserving space.

The sub-committee recognizes a tendency toward the omission of the period in some technical abbreviations and favors the omission, except in cases of general literary composition, as being economical and conducive to the elimination of waste. Some mathematical and chemical terms are, in preferred practice, customarily abbreviated without periods; thus sin, log, Cu, etc.

Do not space the letters of such abbreviations as A.S.H.V.E. (not A. S. H. V. E.).

In text, do not use the exponents for the abbreviations of square and cube nor the negative exponents for terms involving per. The superior figures are usually not available on the keyboards of typesetting and linotype machines and composition is therefore delayed. There is also the likelihood of confusion with footnote reference numbers. These shorter forms are permissible in tables and are sometimes difficult to avoid in text.

Abbreviations

In this initial list of abbreviations for engineering and scientific terms only those most commonly used have been included.

Absolute	abs
Acre	a.
Acre-feet	spell out
Air horsepower	air hp.
Alternating-current (adjective)	a-c.
American wire gage (Brown and Sharp)	B.&S. gage
Ampere	amp.
Ampere-hour	amp-hr.
Angstrom unit	A
Antilogarithm	antilog
Armature	arm.
Atomic weight	at. wt.
Atmosphere	atm.
Average	avg.
Avoirdupois	avdp.
Barometer	bar.
Barrel	bbl.
Baumé	Bé.
Birmingham wire gage	B.w.g.
Board feet	f.b.m.
Boiler horsepower	boiler hp.
Boiling point	b.p.
Brake horsepower	b.hp.
Brake horsepower-hour	b.hp-hr.
Brinnell hardness number	B.h.n.
[8]British thermal unit	B.tu
Brown & Sharp gage	B.&S. gage
Bundle	bdl.
Bushel	bu.
Calorie	cal
Candlepower	cp.
Candlepower-hour	cp-hr.
Center to center	c. to c.
Centigram	cg
Centiliter	cl
Centimeter	cm
Centimeter-gram-second	cgs
Cent	c.
Chain	ch.
Chemical	chem.
Chemically pure	c.p.
Circular	cir.
circular mils	cir. mils
Civil Engineer	C.E.
Coefficient	coef.
Cologarithm	colog
Concentrate	conc.
Conductivity	cond.
Constant	const.
Continental horsepower	cont. hp.
Cord	cd.
Cosecant	csc
Cosine	cos
cost, insurance and freight	c.i.f.
Cotangent	ctn
Counter electromotive force	counter emf
Cubic	cu.
Cubic centimeter	cu. cm., cc (liquid)
Cubic foot	cu. ft.
Cubic feet per second	c.f.s.
Cubic inch	cu. in.
Cubic meter	cu. m
Cubic micron	cu. μ
Cubic millimeter	cu. mm
Cubic yard	cu. yd.
Current density	spell out
Cycles per second	∼
Cylinder	cyl.
Day	spell out
Degree	deg.
[8]Degree Centigrade	C
[8]Degree Fahrenheit	F
Degree Kelvin	K
Degree Réaumur	R
Diameter	diam.
Direct-current (as adjective)	d-c.
Dollar	$

---

[8] Not used in Text of THE GUIDE until approved by *A. S. A.*

Dozen	doz.
Dram	dr.
East	E
East-northeast	ENE
East-southeast	ESE
Electric	elec.
Electric horsepower	e.hp.
Electrical Engineer	E.E.
Electromotive force	emf
Elevation	el.
Farad	f
Feet board measure	f.b.m.
Feet per minute	f.p.m.
Feet per second	f.p.s.
Fluid	fl.
Foot	ft.
Foot-candle	ft-c.
Foot-Lambert	ft-L
Foot-pound	ft-lb.
Foot-pound-second system	fps
Franc	fr.
Free aboard ship	spell out
Free alongside ship	spell out
Free on board	f.o.b.
Freezing point	f.p.
Frequency	freq.
Furlong	fur.
Gallon	gal.
Gallons per minute	g.p.m.
Gallons per second	g.p.s.
Generator	gen.
Grain	spell out
Gram	spell out
Gram-calorie	g-cal
Hectare	ha
Henry	h
High-pressure cylinder	H.P. cyl.
Hogshead	hhd.
Horsepower	hp.
Horsepower-hour	hp-hr.
Hour	hr.
Hundredweight (112 lb.)	cwt.
Hyperbolic sine	sinh
Hyperbolic cosine	cosh
Inch	in.
Inch-pound	in-lb.
Inches per second	i.p.s.
Indicated horsepower	i.hp.
Indicated horsepower-hour	i.hp-hr.
Intermediate-pressure cylinder	I.P. cyl.
Internal	int.
Kilogram	kg
Kilogram-meter	kg-m
Kilograms per cubic meter	kg per cu. m.
Kilograms per second	kg per sec.
Kiloliter	kl
Kilometer	km
Kilometers per second	km per sec.
Kilovolt	kv
Kilovolt-ampere	kv-a
Kilowatt	kw
Kilowatt-hour	kw-hr.

Lambert	L
Latitude	lat.
Least common multiple	l.c.m.
Lineal foot	lin. ft.
Link	l.
Lira	spell out
Liter	l
Liquid	liq.
Logarithm	log
Longitude	long.
Low-pressure cylinder	L.P. cyl.
Lumen	l
Lumen-hour	l-hr.
Lumens per watt	l.p.w.
Magnetomotive force	mmf
Mark	M.
Mass	spell out
Master Car Builders' Standard	M.C.B. Std.
Mathematics (ical)	math.
Maximum	max.
Mean effective pressure	m.e.p.
Mean horizontal candlepower	m.h.cp.
Mean spherical candlepower	m.s.cp.
Mechanical Engineer	M.E.
Megawatt	spell out
Megohm	meg
Melting point	m.p.
Meter	m
Meter-kilogram	m-kg
Mho	spell out
Microfarad	μf
Micromicron	μμ
Micron	μ
Microwatt	spell out
Mile	spell out
Miles per hour	m.p.h.
Miles per hour per second	m.p.h. per sec.
Milliampere	milliamp.
Milifarad	mf
Milligram	mg
Milihenry	mh
Millilambert	mL
Milliliter	ml
Millimeter	mm
Millimicron	mμ
Million	spell out
Million gallons per day	m.g.d.
Millivolt	mv
Mining Engineer	E.M.
Minute	min.
Molecular weight	mol. wt.
Molecule	mol.
National Electric Code	N.E.C.
North	N
Northeast	NE
North-northeast	NNE
North-northwest	NNW
Northwest	NW
Ohm	spell out or Ω
Ohm-centimeter	ohm-cm
Ounce	oz.
Parts per million	p.p.m.
Peck	pk.

Penny (Pence)	d.
Pennyweight	dwt.
Peso	spell out
Pint	spell out
Potential	pot.
Potential difference	p.d.
Pound	lb.
Pound-foot	lb-ft.
Pound-inch	lb-in.
Pounds per brake horsepower hour	lb. per b.hp-hr.
Pounds per square foot	lb. per sq. ft.
Pounds per square inch	lb. per sq. in.
Pound Sterling	£
Power factor	spell out
Primary	pri.
Quart	qt.
Radian	spell out
Reactance	react.
Reactive kilovolt-ampere	r.kv-a
Reactive volt-ampere	r.v-a
Revolutions per minute	rpm
Revolutions per second	r.p.s.
Root mean square	r.m.s.
Round	rd.
Secant	sec
Second	sec.
Shaft horsepower	s.hp.
Shilling	s.
Sine	sin
South	S
Southeast	SE
South-southeast	SSE
South-southwest	SSW
Southwest	SW
Specific gravity	sp. gr.
Specific heat	sp. ht.
Square centimeter	sq. cm
Square foot	sq. ft.
Square inch	sq. in.
Square kilometer	sq. km
Square meter	sq. m
Square micron	sq. μ
Square millimeter	sq. mm
Square root of mean square	r.m.s.
Stere	s
Tangent	tan
Temperature	temp.
Tensile strength	tens. str.
Thousand	M
Ton	spell out
Ton-mile	spell out
Twaddell	Twad.
United States Pharmacopeia	U.S.P.
Versed sine	vers
Volt	spell out
Volt-ampere	v-a
Watt	spell out or w
Watt-hour	w-hr.
Watts per candlepower	w.p.c.
Weight	wt.
West	W
West-northwest	WNW
West-southwest	WSW
Yard	yd.
Year	spell out

CATALOG DATA SECTION

(Pages 534–874)

with an

INDEX TO MODERN EQUIPMENT

(Pages 875–884)

and

INDEX TO ADVERTISERS

(Pages 885–888)

Carrier Engineering Corporation

Atmospheric Conditioning Corporation

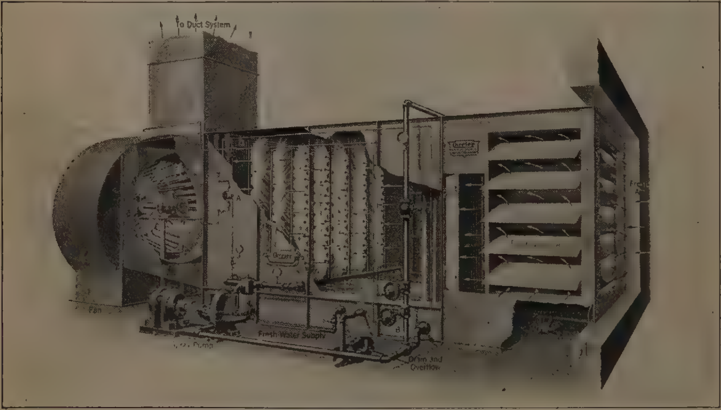
Offices and Laboratories: 850 Frelinghuysen Ave.
Newark, N. J.

New York, 39 Cortlandt Street   Philadelphia, Land Title Building   Boston, 1011 Statler Building
Chicago, Burnham Building   Cleveland, Union Trust Building   Detroit, 2626 Buhl Building
Washington, D.C., 418 Washington Loan & Trust Bldg.   Kansas City, Manufacturers Exchange Bldg.
Dallas, 2706 Commerce Street   Los Angeles, 748 E. Washington Street

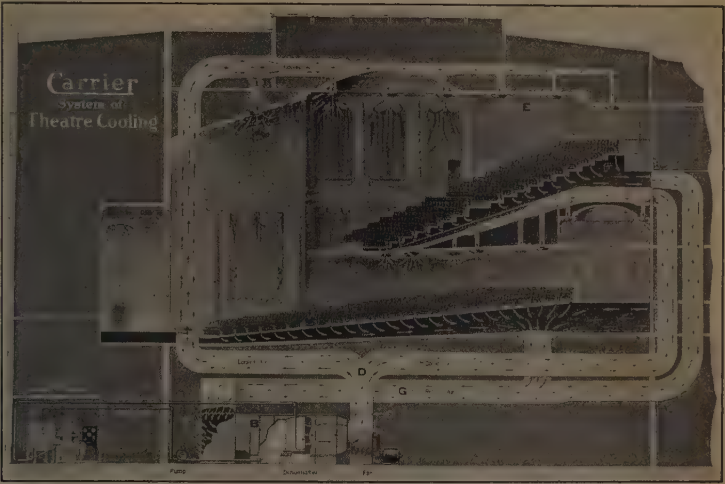
---

Air Conditioning Systems—Especially designed for Textile Mills, Candy Factories, Bakeries, Flour Mills, Drug and Chemical Plants, Printing and Lithographic Plants, Packing Plants, Laboratories, Theaters, Public Buildings and for numerous other industries where there are requirements for clean air uniformly distributed and automatically controlled at any desired condition of temperature and humidity. Equipment, installation and results are guaranteed. *Ask for Bulletin 58-G, or request specific information.*

Cooling and Air Conditioning in Public and Private Buildings—With a background of more than twenty-five years' experience in the design and application of Air Conditioning equipment, the Carrier organization has logically led in applying this science to the maintenance of conditions of physical comfort of people congregated within buildings. In Theaters, Auditoria, Hospitals, Hotels, Department Stores, Office Buildings, Factories and Mansions it is now possible to maintain ideal conditions of physical comfort, regardless of seasons or outdoor weather. Winter conditions require humidification and heating. In Summer, cooling and dehumidification must be accomplished. Nearly 3,000 Carrier installations in more than 200 different industries are producing the desired conditions unfailingly. We are at all times pleased to cooperate with Architects, Engineers and Builders in the design and installation of Air Conditioning equipment within buildings under their direction. *Write for the book, "Theater Cooling," G-1.*

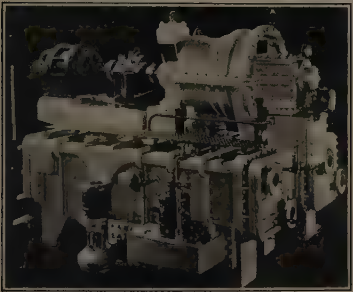


A Typical Carrier Humidifier or Dehumidifier showing the automatically controlled fresh and return air dampers, the spray chamber with pumping and water heating equipment and, on the left, the fan which delivers the air to the duct system



Cross Section of a Typical Theater equipped with a Carrier System for Cooling, Dehumidifying and Purifying the Air in Summer, and Warming, Humidifying and Purifying the Air in Winter. Note the use of Carrier Centrifugal Refrigeration in connection with this equipment

Carrier Centrifugal Refrigeration—This system is an innovation in the production of cold. The refrigerant is a harmless, inoffensive liquid—"Carrene." The compressor is a simple centrifugal unit similar in construction and operation to a centrifugal pump. Control is automatic. Space requirement is one-quarter that of any other system of like capacity. This system is used in connection with all Carrier cooling and dehumidifying installations. Complete safety, simplicity and efficiency of operation are assured. *Details on request.*



A Complete Carrier Centrifugal Refrigeration Unit. Safe. Simple. Automatic

The Carrier Unit Air Conditioner—A simple, efficient, compact, portable and inexpensive Unit which performs every function of the Carrier Central Station System. It washes the air, cools, heats, humidifies, dehumidifies and produces effective ventilation and air circulation. Capacity 2,500 cu. ft. of conditioned air per minute. Entire operation by 1 hp. motor. This is not a miniature humidifier copied from the central station equipment, but is an entirely new and novel design developed to place *Manufactured Weather* within the means of *any* manufacturer. *Ask for "The Carrier Unit Air Conditioner," Bulletin 52-G.*

The Cooling & Air Conditioning Corp.

Executive Office

11 West 42nd Street, **New York, N. Y.**

BRANCH OFICES—CHICAGO, PHILADELPHIA, DETROIT

Engineers and Contractors

Automatically Controlled Air Conditioning Systems: Cooling—Humidifying—Dehumidifying—Heating—Ventilating—Drying—Ross Paper Conditioning—Coolairco Bakery Systems

---

"Coolairco" Equipment in Apparatus Room of Large Printing Establishment

Producing and maintaining the ideal atmospheric condition within a plant to insure constant uniformity of both quantity and quality of production is today an important function of modern manufacturing methods. Heating, ventilating and production engineers agree that real efficient manufacturing in most fields is only possible in a plant that is not affected by the constantly changing outside temperature and humidity values.

"Coolairco" Systems are specified in more than fifty different industries to properly overcome manufacturing difficulties through supplying, and constantly maintaining, automatically, any required and pre-determined degree of temperature and humidity—high or low—to insure the same conditions, day in and day out, for maximum operating efficiency.

The broad and successful experience of our engineering staff insures the most intelligent handling of cooling and air conditioning problems in plants of any size, in any field, requiring such equipment—Textile, Rayon, Printing, Lithographing, Confectionery, Chemical, Baking, Tobacco, Paper, Dairy, Theatres, Hospitals, Stores, Cafes, etc. This capable engineering service is available to assist interested executives.

Maryland Air Conditioning Corporation

Successors to
Bentz Engineering Corporation

Manufacturers of Air Conditioning Equipment for Every Industrial or Commercial Purpose

Main Offices and Factory
Clarkson, McComas, Donaldson and Race Street,
New York **Baltimore, Maryland** **Atlanta**

"CHILLBLAST"
(Reg. U. S. Patent Office)

Simple and compact in design, rugged in construction, highly efficient in operation, the Chillblast provides an economical means of maintaining desired temperatures and humidities and of cleansing air of dust, soot and other atmospheric impurities.

There are no delicate parts subject to heavy wear—**no spray nozzles** to become clogged. Since the water which forms the water curtains is not under pressure there is consequently a material saving effected in power required for pumping. In the Chillblast, the air is drawn through multiple water curtains, over cooling coils, thence through the eliminator plates which remove entrained moisture. Practically any temperature and humidity may be constantly maintained regardless of outside weather conditions.

The Chillblast has a wide application as an air conditioner, cooler and dehumidifier. Chillblasts and air conditioners have been satisfactorily applied to many industries such as tobacco, confectionery, baking, food products and leather and to such institutions as theatres, hotels, restaurants, schools and hospitals. This apparatus is made in a number of standard sizes applicable to large and small installations.

Other standard equipment manufactured by this company include:

- The "Coldbed"—used extensively to cool and set quickly candy or icings.
- Proof Boxes—used throughout the baking industry.
- Proof Box Air Conditioners.
- Starch Drying Systems.
- Varnish Drying Kilns.
- Air Washers.

Air conditioning equipment manufactured by the Maryland Air Conditioning Corporation is applicable to any industry or establishment and the company's engineers are prepared to make recommendations covering any air conditioning application.

Niagara Blower Company

AIR ENGINEERING EQUIPMENT AND SYSTEMS

Factory and Engineering Office—673 Ontario St., Buffalo, N. Y.
Sales Office - - - - - - - - - - - - - 95 Liberty St., New York City

Air Conditioning, Humidifying, Dehumidifying, Heating, Cooling, Ventilation Equipment. *Niagara Air Conditioner, Niagara Fan Heater.* Drying, Dehydrating, Solvent Recovery, Pneumatic Conveying Systems. Niagara Tubefin Heating Surface. Corrosion Resisting Equipment for Industrial Processes.

NIAGARA AIR CONDITIONER

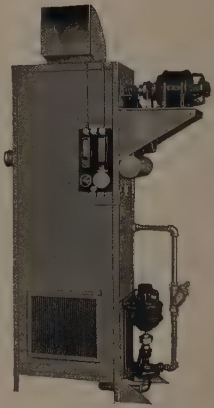
Maintains always constant temperature and relative humidity, makes any change in relative humidity or furnishes moisture or dryness to any desired proportion in air in the processing of hygroscopic materials.

Furnishes heat, maintaining any desired temperature, or cools (with the use of refrigeration or cold water).

Cleans the air more effectively than ordinary spray washers.

The Niagara Air Conditioner is accurate because of its new and superior temperature and humidity control. It has 30 to 50 per cent greater cooling effect for the size of the machine because it *secures saturation* within small space.

Niagara Air Conditioners have been thoroughly proven in actual operation. There are no untried or over delicate parts. Nia-Fin Heating Coil used is all aluminum, welded by special process, good for 150 lb. working pressure.



Niagara Air Conditioner

RATED OUTPUT CAPACITIES—NIAGARA AIR CONDITIONER*

WIDE UNIT

Unit No.	Fan Motor		Pump Motor		Cu. Ft. Air Per Min.	Lbs. Air Per Min.
	R. P. M.	H. P.	R. P. M.	H. P.		
125 WB	720	½	1440	2	2600	195
125 WF	720	¾	1440	2	2940	220
160 WB	1160	2	3500	2	4120	309
160 WB	870	1¼	3500	2	3540	266
160 WB	860	1	3500	2	3100	233
160 WB	670	½	3500	2	2420	182
160 WB	570	¼	3500	2	2060	154
225 WB	720	1	1440	3	4800	360
225 WF	720	1½	1440	3	5300	398
260 WB	1160	5	1730	3	7750	581
260 WB	865	1½	1730	3	5800	435
260 WF	850	2	1730	3	6200	465
260 WB	690	1	1730	3	4600	345
260 WB	570	½	1730	3	3800	285
325 WB	720	1½	1740	3	6900	518
325 WF	720	2	1440	3	7500	563
360 WB	1150	5	1730	3	11,000	825
360 WB	870	3	1730	3	8300	623
360 WF	850	3	1730	3	8850	664
360 WB	685	1	1730	3	6550	492
360 WB	570	¾	1730	3	5450	409

NARROW UNIT

Unit No.	Fan Motor		Pump Motor		Cu. Ft. Air Per Min.	Lbs. Air Per Min.
	R. P. M.	H. P.	R. P. M.	H. P.		
125 N	1430	½	1440	2	1600	120
125 N	715	⅛	1440	2	800	60
160 N	1160	⅓	3500	2	1290	97
160 N	860	⅛	3500	2	960	72
225 N	1435	1	1440	2	3015	227
225 N	715	⅛	1440	2	1510	123
260 N	1145	½	3500	2	2410	181
260 N	870	¼	3500	2	1840	138
260 N	690	⅛	3500	2	1460	110
325 N	1430	1½	1440	2	4590	344
325 N	730	¼	1440	2	2320	174
360 N	1140	¾	3500	2	3640	272
360 N	850	⅓	3500	2	2700	203
360 N	690	¼	3500	2	2200	165

Units Nos. 125, 225 and 325 are for 25-cycle current.

Units Nos. 160, 161, 260, 261, 360 and 361 are for 60-cycle current.

---

*The cubic feet contents of a room which an air conditioning unit will handle is dependent upon the relative humidity and the amount of heat to be absorbed (from lights, power consumed in running machinery or other source of heat)—the higher the humidity and the greater the amount of heat, the less room space in cubic feet contents with a given sized unit handle. The capacities given are only to serve as a rough guide for average conditions; even then the capacity may vary over a wide range as given.

NIAGARA FAN HEATER

For the heating and ventilating of industrial plants, foundries, machine shops, garages, assembly floors, large areas and high ceiling buildings. Especially adapted to conditions where ventilating as well as heating is required—packing plants, laundries, dairies, dye houses, paper mills.

Put the Heat Immediately Where Needed—

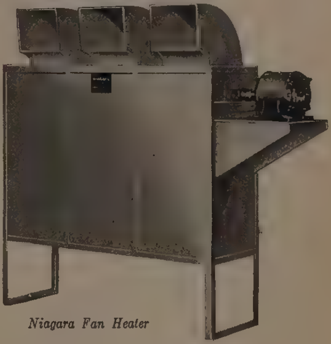
Niagara Heating Units cut the time required to bring a room to working temperature by delivering the warm air immediately into the working zone.

Efficient Heating—

By recirculating air in the working zone, Niagara Heating Units prevent the waste of heat caused by overheating the upper part of the room to obtain normal temperature below. Because of this saving and the large amount of air handled in relation to the heating surface, Niagara Heating Units consume less fuel in maintaining desired uniform temperatures.

Construction Advantages—

Specially designed, high efficiency fan produces large capacity with slower speed and more quiet operation. Heating surface furnished is Nia-Fin, all aluminum tube and fin coil with cast aluminum header welded by special process good for 150 lb. working steam pressure. Steel coil with aluminum fins also furnished if desired.



Niagara Fan Heater

RATED OUTPUT CAPACITIES—Dimensions and Weights

	Unit No.	R.P.M.	Motor H.P.	Cu. Ft. Air per Min.	Entering Air at 60° 5 Lb. Steam			Overall Height	Length Casing	Width Casing	Net Weight
					Outlet Temp. °F.	B.t.u. per Hour	Lb. Cond. per Hour				
Narrow Units	125 N	720	⅛	1115	139	85200	88	103″	31″	30″	444 lb.
		1440	¾	2175	124	128300	133				
	160 N	860	⅛	1315	134	95700	99				
		1160	⅛	1775	129	121000	125				
	225 N	720	1/6	2110	139	161000	167		51″		563 lb.
		1440	1½	4100	124	261000	270				
	260 N	860	¼	2500	134	182000	188				
		1160	¾	3330	129	226000	234				
	325 N	720	¼	3040	139	232000	240		70″		638 lb.
		1440	2	5920	124	377000	391				
	360 N	860	⅕	3620	134	263000	272				
		1160	1	4830	129	328000	340				
Standard Width Units	125 W	720	1	4340	124	274000	277	* 86″	40″	20″	634 lb.
	126 W	720	1	4400	132	308000	311				
	160 W	860	1	4340	124	274000	277				
	225 W	720	2	8680	124	542000	554		74″		968 lb.
	226 W	720	2	8800	132	616000	623				
	260 W	860	2	8680	124	542000	554				
	325 W	720	3	12600	124.5	800000	808		90″		1259 lb.
	326 W	720	3	12800	132.6	900000	909				
	360 W	860	3	12600	124.5	800000	808				

*For complete data on final temperatures and B.t.u. output capacities at steam pressures from 2 to 200 lb. and entering air temperatures from—20° F. to 160° F., see Bulletin No. 3, Niagara Blower Company.

Parks-Cramer Company

AIR CONDITIONING ENGINEERS AND CONTRACTORS

Fitchburg, Mass. **Boston, Mass.** **Charlotte, N. C.**

PRODUCTS:

Humidifying Apparatus and Equipment of all types and Air Conditioning Systems.

INDUSTRIES SUPPLIED (Partial List)

Cotton, Woolen, Worsted, Silk and Rayon, Printing and Lithographing, Cigar and Tobacco, Clothing, Paper and Envelope, Leather and Shoes, Wood Working, Cereals, Storage of Perishable Food Products, Ceramic Products, Asbestos Products, Mechanical Cotton and Woolen Products, Starch and Dextrine, Insulated Cable, Celluloid, Chicken Hatcheries, Art Galleries, Glassine Paper, Cement, Hospitals, Fine Homes.

TYPES OF APPARATUS:

Parks-Cramer Company is the manufacturer of six different types of air conditioning apparatus recognized as standard. They are:

TURBO HUMIDIFIERS
SPRAY HUMIDIFIERS
HIGH DUTY HUMIDIFIERS
CENTRIFUGAL HUMIDIFIERS
CENTRAL STATION SYSTEMS
UNIT AIR CONDITIONERS

We also manufacture both the wet and dry bulb regulator and the hygroscopic regulator.

Our engineers are prepared to study any problem and to recommend the type of system that will give the desired results. Being manufacturers of all types of systems, our experience has been with all conceivable problems. A study of the above list of industries served will show that we have dealt with practically every known hygroscopic substance.

Turbo Humidifier—An "atomizer" type using compressed air to break up the water and produce a fine spray. The use also of centrifugal force improves the quality of the spray and reduces the amount of air used. Best suited to low posted rooms or where, for purposes of distribution, many units are desirable. Water is not under pressure and air pressure is low.

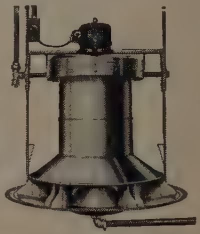
This type of head contains no moving parts, it is very easy to keep clean, and if it stops it cannot cause water damage. At very slight additional expense air can be drawn from the humidifier lines for air cleaning of machinery.

Turbo Humidifier

Spray Humidifier, Type HS—A water under pressure type. Water at about 150 lb. pressure impinges on a bronze pin and spray is created. The casing construction allows only the finest to escape. The rest is collected in a pan, returned to a filter to be purified and used again. Casing is made of heavy copper, and has no openings to leak or joints to keep packed. Pan is of heavier copper, braced to give adequate strength. No bolts or nuts to catch lint or unscrew and get lost when cleaning. Nozzle has a fixed orifice and is easily renewed at low expense.

High Duty Humidifier, Types HDD and HDS—Similar to the spray humidifier with the addition of a direct connected motor-driven fan. A miniature Air Washer. The warm and relatively dry air enters from above and is blown through a sheet of fine spray. It is discharged from the annular opening below at high velocity in a complete and nearly horizontal circle.

Centrifugal Humidifier



High Duty Humidifier

The spray is flattened and spread by the air currents and is quickly evaporated; the water is rapidly and thoroughly diffused over a large area.

Central Station

In winter, steam under thermostatic control may be admitted to a filter tank so that the circulated water may be held at any desired temperature. Units of high capacity are used where requirements are most severe and a high-heat factor is present.

Evaporation per unit is much greater than in the atomizer or the spray head.

Centrifugal Humidifier—Uses water without pressure and eliminates air compressors and pumps. Best suited to small rooms that are free from lint or dust.

Central Station Air Conditioning Equipment—This consists of a centrally located apparatus for supplying the maximum of moisture required and changing the air with ample frequency; it usually includes indirect radiation for heating; suitable ducts or flues for conveying and distributing the conditioned air. Additional provision may be made for removal of all impurities in the air. Regulation in multiple department equipments is provided by automatic humidity and temperature regulators.

Advantages of this type are: immediate supply of heat and moisture in extremely cold weather; great reduction of room temperature in extremely hot weather is possible by refrigerating the water; responsibility for supervision placed on plant engineering force. However, the initial and operating costs are high.

Unit Air Conditioner—This type of small central station apparatus is suitable for laboratories, small manufacturing departments, etc. It is built in a variety of forms to suit many individual requirements.

Regulation—A humidification system can be no better than its regulation. Humidification to be economical must constantly balance evaporation with air change. Moisture demands vary greatly throughout the day, month and year. The regulators automatically turn on and off the humidifiers as this demand changes.

Psychrostat

"Psychrostat"—This is one of the most sensitive, accurate and rugged regulators made. It operates on the principle of the sling psychrometer, universally recognized as the standard means of measuring humidity. An injector draws air through the dry-bulb compartment, then saturates it, and sends it on through the wet-bulb compartment. In each compartment is a sensitive, elastic metal bellows that expands and contracts with changes in temperature. These are connected by a suitable linkwork to a slide valve so that the differential temperature actuates the control valve. It is evident from its construction that the Psychrostat needs a minimum of maintenance and adjustment.

Hygroscopic Regulator—This device is offered for use where less exacting requirements permit the economy of its lower cost. It employs human hair as the hygroscopic element, the most sensitive and dependable hygroscopic material known. Its rugged and simple construction makes it the best moderately priced regulator on the market.

Engineering Service

The broad experience of Parks-Cramer Company's engineers in all fields of humidification engineering is available at your request.

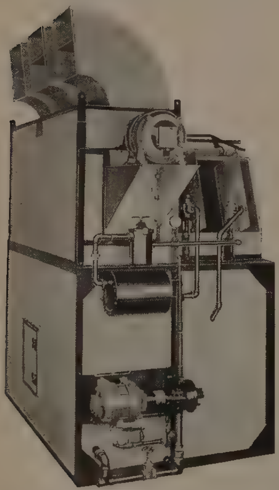
York Heating and Ventilating Corp.

York Building, 16th and Samson Streets **Philadelphia**

Branch Offices and Representatives in All Principal Cities

York Air-Conditioning Units for Air Conditioning in Industrial Plants of All Kinds

YORK
AIR-CONDITIONING
UNIT



York Air-Conditioning Unit, complete, with water circulating pump, water heater, automatic dampers, and automatic temperature and humidity control.

	Size Unit	R.P.M. of Fans	H. P. of Fan Motor	C.F.M. Delivered
YORK AIR-CONDITIONING UNITS	2422* or 3422**	1750	¾	2,500
		1160	½	1,660
	2434* or 3434**	1750	1½	5,000
		1160	½	3,320
	2453* or 3453**	1160	3	10,000
		870	1½	7,500
	2412***	1750	¾	2,000
		1160	½	1,325

*Humidifying Unit.
**De-Humidifying Unit.
***Proof Box Unit.

Unit System of Air Conditioning—

These units will wash, and cool or heat, humidify or dehumidify the air. Complete air conditioning in a compact, highly developed unit.

The basis of operation is the York Heat-Diffusing Unit, amplified and developed to include the functions of scientific air conditioning.

Any floor or partitioned department may be controlled effectively as to atmospheric conditions, without reference to any other floor or department.

Operation—

The air passes through two spray chambers and a series of baffle plates. It is then heated and blown out horizontally at high velocity above the heads of the workers. This exclusive York feature makes possible an even distribution over a large area—and thereby reduces the number of units required.

Simple regulating controls, easily set, govern both temperature and humidity. An effectively conditioned atmosphere results.

Advantages—

Every Unit is mobile—can easily be shifted. The work of installation is simple. Complete flexibility of operation is possible.

Data Required—

Blue-prints and full information as to size and construction of building or department into which the Units are going; full information as to material to be conditioned and amount handled; available location for Units and location of steam, water and electric lines.

Air-Cooling Unit—

The York Air-Cooling Unit is a self contained completely assembled unit designed for use in cold storage rooms. Brine or ammonia is used as the cooling medium.

By automatic control any desired temperature may be maintained.

Strandwitz & Scott, Inc.

Manufacturers and Distributors of Webster Air Washers, Generator Washers and Coolers; General Sheet Metal Contractors

537-549 S. Second Street, **Camden, N. J.**

Representatives

CHICAGO, ILL.	S. C. Bloom & Co.	MINNEAPOLIS, MINN.	Cash Co.
CINCINNATI, OHIO	W. C. Green Specialty Co.	PITTSBURGH, PA.	Robinson & Stranger
INDIANAPOLIS, IND.	S. E. Fenstermaker & Co.	MONTREAL, CANADA	Darling Bros., Ltd.

PRODUCTS

Equipment for Cleansing the Air and for Generator and Transformer Ventilation; Air Washers; Spray Nozzles; Webster System of Humidity Control.

Air Washers

Suitable for practically every type of building for either cleansing or cooling the air or both, for the comfort of the occupants or to maintain high efficiency among employees or students.

The Type "A" air washer is designed primarily for cleansing and cooling where a moderate cooling effect by evaporation is desired.

Guaranteed when operating at rated capacity to remove 98 per cent of all solid matter contained in the entering air, and to cool this air 70 per cent of the wet bulb depression.

The Type "B" air washer is designed for cleansing and cooling the air in public buildings and industrial plants where the greatest possible cooling effect by evaporation is desired.

The Type "C" air washer is designed for cleansing and cooling where space conditions are limited.

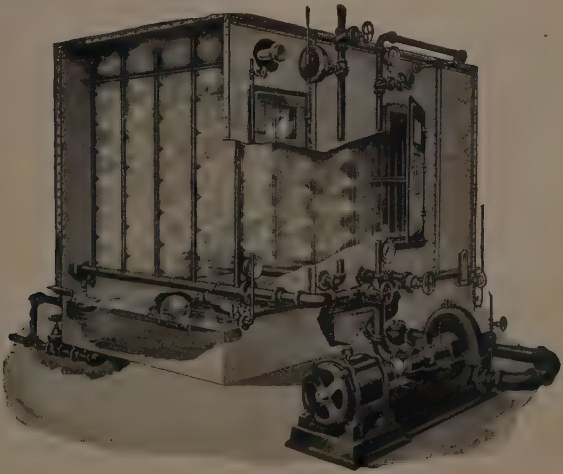
Guaranteed when operating at rated capacity to remove 95 per cent of all solid matter contained in the entering air and to cool the air 60 per cent of the wet bulb depression.

Humidifiers

The Webster Humidifier is designed for adding moisture to the air entering through the ventilating system and thereby maintaining automatically a uniform relative humidity.

Humidity Control

The Webster System of Humidity Control may be applied to the various types of Webster Air Washers and Humidifiers. Perfect in principle and accurate in operation, the chief controlling thermostat subject to water, a medium four times the specific heat of air.



View of Webster Air Washer and Humidifier

Knowles Mushroom Ventilator Co.

41 North Moore Street, New York

Knowles Air Diffusers for Auditoriums of Theatres, Churches, Schools

PRODUCTS:—Cast Iron and All-Steel Adjustable Mushroom Ventilators; Aisle Hood, Tu-Way and Camelback Air Deflectors; Round and Oblong Gallery Riser Vents.

Knowles *Aero Valve*—The Improved Mushroom Air Diffuser

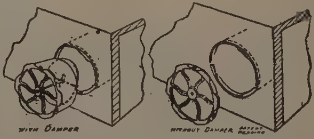
The newest Knowles product. An up-to-date mechanically correct air unit of fixed height made of heavy rolled steel. Also furnished with **Cast Iron** Dome Cap and Strong **Cast Iron** Supports bearing on floor flange. Easy to regulate and install and low in price. Combines high efficiency with convenient adjustment affording finest control of air by simply turning screw on top of cap. Can be positively locked at desired adjustment and the only mushroom made which can not be taken apart before or after installation.

Knowles *Nu-Notch* Mushroom Ventilator or Air Diffuser

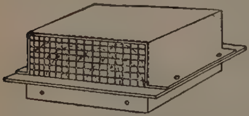
The ideal cast iron mushroom. Head has three outer bearings and is absolutely rigid. Ten recessed notches give close regulation of air. Locked into positive adjustment by tightening head screw. Supplied with dome or flat tops. Three screwholes in floor flange for fastening to wood, or three angle L lugs for setting in concrete, or three set-screws in floor collar for fastening to sleeve.

Size	Cu. Ft. per Min. at 300 ft. Vel.	Area, Sq. Ft.	Weight Lbs.
5″ diam.	42	0.1364	4
6″ "	60	0.1964	4¾
7″ "	81	0.2673	6½
8″ "	105	0.3491	9
10″ "	165	0.5454	14½

Specifications—Furnish and install where indicated on drawings or as hereinafter specified (5-in.), (6-in.), (7-in.), (8-in.), (10-in.), (Dome Top), (Flat Top), **Nu-Notch** Cast Iron Mushroom Air Diffusers with recessed notches for the permanent adjustment of mushroom caps at any desired opening together with center locking screw feature as manufactured by Knowles Mushroom Ventilator Co., New York, N. Y.



Knowles *Disc-Loc* Gallery Riser Ventilators are designed to insure better control of air. Round holes in the gallery risers do not weaken the construction but, on the contrary, with the cast iron rings it is actually strengthened. The sleeve is a plain galvanized iron cylinder, with a ½ in. turnover flange, and with a special cast iron ring, riveted flush to the inside front end. Sleeves are grouted in when concrete is poured. The cast iron grill is quickly inserted and locked by a simple twist motion—no bolts, screws or springs. Furnished with or without damper to fit same rings. MADE IN FOUR SIZES (See Booklet).



***Tu-Way* Air Deflectors** are designed to give maximum area of discharge of air with minimum fixed height. The air is discharged at both ends along the row of seats. Do not interfere with the back of chair seats when they are raised. Made of Heavy Cast Iron with heavy wire screens locked into grooves at each end. Damper easily adjusted with screwdriver from top of cap. MADE IN FIVE SIZES (See Booklet for detail).

Standard Aisle Hood Air Deflectors are used to throw the fresh air out into the aisles in one direction. A curved damper reduces friction loss.

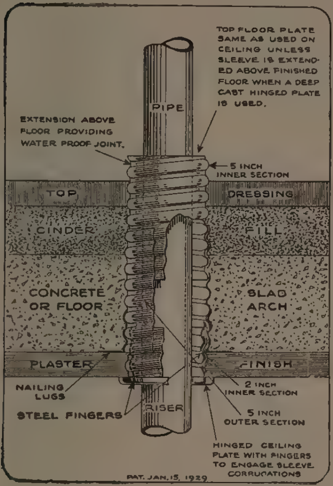
Small size	8 in. long	4½ in. wide	4½ in. high
Large size	8 in. long	6 in. wide	6 in. high

Send for New Booklet of Complete Engineering Data

Knowles Pipe Sleeve Co.

41 North Moore Street, **New York, N. Y.**

A Standard Extensible Sleeve for all Kinds of Buildings and all Sizes of Pipe


TOP FLOOR PLATE SAME AS USED ON CEILING UNLESS SLEEVE IS EXTENDED ABOVE FINISHED FLOOR WHEN A DEEP CAST HINGED PLATE IS USED.
PIPE
EXTENSION ABOVE FLOOR PROVIDING WATER PROOF JOINT.
5 INCH INNER SECTION
TOP
DRESSING
CINDER
FILL
CONCRETE OR FLOOR
SLAB ARCH
PLASTER
FINISH
NAILING LUGS
STEEL FINGERS
RISER
2 INCH INNER SECTION
5 INCH OUTER SECTION
HINGED CEILING PLATE WITH FINGERS TO ENGAGE SLEEVE CORRUGATIONS
PAT. JAN. 15, 1929

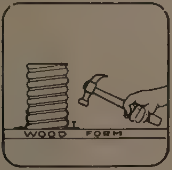
SUPER SLEEVE

PAT. JAN. 15, 1929

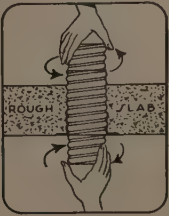
Provides the original form for hole through concrete, fill and cement dressing and is adjustable for each stage of construction as it progresses. Provided with lugs for nailing to form before concrete is poured. Provides form for plaster finish around pipe on ceilings. Provides Hinged Plates which may be fitted around pipes after all construction work is completed. Plates will remain permanently in position, becoming an integral part of the sleeve. Protects piping from external erosion from contact with concrete, cinder fill and cement. Eliminates expensive "after-patching." Is strong enough to withstand construction abuse, yet light and easy to handle. Saves **Time—Labor—Expense** in providing and setting special sizes to order. Eliminates clipping sleeves to length on job.

Sizes to Use and Specify

FOR SIZE PIPE	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	3 1/2″	4″	5″
Use Diameter Outer Section	2″	2″	2″	3″	3″	4 1/2″	4 1/2″	4 1/2″	6″	6″
Use Diameter Outer Inner Section	2″	2″	2″	3″	3″	4 1/2″	4 1/2″	4 1/2″	6″	6″
Use Diameter Short Inner Section	2″	2″	2″	3″	3″	4 1/2″	4 1/2″	4 1/2″	6″	6″
Use Hinged Plate with Steel Fingers	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	3 1/2″	4″	5″



Outer section nailed to form holds SUPERSLEEVE *firmly in place until concrete slab is poured and set*



After all construction is completed snap our patented plate around pipe and twist up flush against finished ceiling, floor or wall surfaces, thus locking plate permanently into place

When Ready to Lay

fill and top cement dressing extend top inner section to desired height by a simple twist of the hand. Will remain extended as set and can be quickly altered if necessary before cement hardens. When ready to plaster ceiling extend the short inner section below slab **Flush to Level of Finished Ceiling.**

Send for New Booklet for Complete Data

Midwest Manufacturing Company

INCORPORATED

BRADFORD **PENNSYLVANIA**

Midwest Canada, Ltd. **Montreal, Canada**

Branches in Principal Cities

Manufacturers of

MIDWEST AIR FILTERS

Midwest Unit Filters

Unit installations are built in wall-type set-ups to deliver the required air capacity and are assembled in angle iron frames to fit the space available. Midwest cells are easiest to install and handle. They automatically snap into place and require no corner clips. Rigid one-piece frames provide durable, leak-proof joints. Filter medium of progressively increasing density provides maximum dust holding capacity. Filter area is 19 per cent larger than other styles of filter units, making for low resistance and efficiency of 97 to 99 per cent guaranteed. Can be cleaned by steam or hot water hose. Complete recommendations, drawings and data furnished without charge.

Midwest Unit Filters are based upon the unit principle of construction, each cell being a complete and interchangeable unit. The filter cell proper consists of a heavy, welded box-like frame with expanded metal front and back, containing a series of strong, specially shaped filter sheets, so arranged as to provide progressively increasing density from front to rear of the cell. Each cell has a capacity of 2 lbs. of dust before cleaning is necessary.

Sinuous Vertical Model SV

A Nine-Cell Unit Filter

Midwest Automatic Self-Cleaning Filters

The Midwest Vertical Model SV illustrated below, incorporating the principle of sinuous "Controlled" air flow, represents a decade's notable work in automatic air filtration.

The filter consists of a series of scientifically bent and spaced filter plates, which are washed and charged by means of a specially prepared filter oil, called Viscosine, which is automatically, at stated intervals, pumped over same. The drive of the flushing mechanism is conveniently located on one side of the filter where it can be reached from the outside of the air duct. Straight, rectangular lines facilitate connection to the air ducts and make a neat, compact installation greatly in contrast to the bulky air filtering devices with which contractors have had to contend in the past. Efficiency is 96 to 99 per cent guaranteed and resistance through the filter is .20 in. water gauge.

National Air Filter Company

INCORPORATED

Manufacturers of Air Filters

205 Central Avenue **Louisville, Ky.**

The "Airmat" Filter—Dry Type

Servicing the "Pocket" Type

The basic element in this type is "Airmat"—a recently developed filtering medium. It is made up in the form of sheets two feet square, composed of multiple layers of a dry fibrous textured material, each layer containing countless tiny openings. Six of such layers held loosely together by embossing form the filter mat used for average conditions. "Airmat" offers very low resistance to air flow, and at the same time retains all the dirt particles in the mazes of the filter mat.

In operation the "Airmat" sheet is held in place between two metallic screens, mounted on a light metal frame, called a "pocket"—one sheet on each side of the pocket. These pockets in turn are supported by a skeleton frame and are held firmly in place against a felt seal by spring locking devices. A frame holding five pockets is the basic unit. These unit frames can be built up and bolted together to fit almost any space available.

The "Airmat" sheet is allowed to remain in service until thoroughly filled with dirt, when it is removed, thrown away, and a clean sheet inserted. The vibrator enables the operator to dislodge the bulk of the accumulating dirt, and thereby greatly extend the service obtained from the sheets. The useful life of "Airmat" sheets will vary directly with the dirt content of the air and the hours of daily service. The cost of new sheets is low and the task of replacement simple.

The "Two Pass" Filter—Oil Type

Group of "Two Pass" Unit Sections

This type is an adaptation of the original "Phoenix" Constant Effect filter made by the same company. The double-pass principle of the "Phoenix" is retained with some advantages added along the line of unit construction. The filtering medium is composed of multiple layers of knitted copper ribbon and coarser outer layers of expanded metal. This is made up in individual elements which are connected so as to form a flexible, endless curtain. This curtain operates over supporting wheels at the tops and, at the bottom, dips into a tank of oil, which removes the dirt by solvent action. The dirt particles settle by gravity to the bottom of the oil, forming a sludge which is readily removed by means of a simple scraper. This service is required only at long intervals. New oil is then added to replenish that which was removed with the sludge.

The "Two Pass" filter is made in unit sections each one 2 ft. 3 in. wide and of any height up to 12 ft. 4 in. over all. Each section is shipped completely assembled. Where several sections are required they are simply bolted together to form a single group. No other framing is necessary. The sheet metal duct work is readily attached to the frame work of the filter.

The filter is equipped with a small electric motor working through a reduction gear, moving the curtain very slowly. By means of a time clock the filter is automatically operated a few minutes each day which is sufficient to thoroughly clean the curtain of its accumulated dirt and keep it coated for further service.

Reed Air Filter Co., *Incorporated*

Factory and General Offices:
202 Central Avenue, **Louisville, Ky.**
District Representatives in Principal Cities

Reed Air
filters

Reed Air Filters—Multi-Panel Continuous, Streamline Self-Cleaning and Standard Unit Types—provide a simple, efficient, economical method of supplying clean air for general ventilation and industrial processes.

The Reed Standard Unit Air Filter—the original Reed Air Filter, introduced over seven years ago—continues to be widely used today, particularly for small installations which do not justify the cost of automatic operation, or for large installations where the labor for maintenance is readily available.

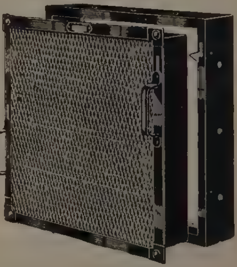
Low first cost and ease of installation resulting from standard unit construction combined with high efficiency in dust removal and low operating cost makes the Reed Unit Filter the most economical of all air cleaners.

Reed Multi-Panel Air Filter of 2½ No. 48/10 Sections. Capacity 34,500 c.f.m.

The Reed Streamline Air Filter—is an automatic filter of the self-cleaning type, employing the streamline principle of air cleaning which offers many advantages, including high efficiency in dust removal and low resistance to air flow. The Streamline Filter is self-cleaned by the flushing method which necessitates shutting off the air supply while cleaning the filter—thus limiting its use to intermittent service such as general ventilation and certain types of industrial applications which do not require continuous 24-hour operation.

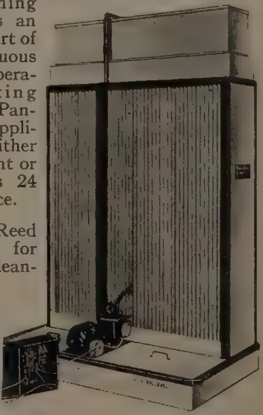
A Reed Air Filter Unit

Consisting of cell and frame. The units are bolted together to form a filter of any capacity or dimensional requirement.



The Reed Multi-Panel Air Filter—developed especially for heavyduty uninterrupted service, represents the most advanced practice in modern air filtration. Its efficiency, while guaranteed 98 per cent, is more nearly perfect air cleaning than ever before attained. The unique overlapping panel construction of the filter curtain combines the air-cleaning and self-cleaning features as an integral part of the continuous cycle of operation, making the Multi-Panel Filter applicable to either intermittent or continuous 24 hour service.

There is a Reed Air Filter for every air cleaning need.



Reed Streamline Air Filter of 1½ No. 62 Sections.

Capacity 18,000 c.f.m.

The following Bulletins contain complete Engineering Data and Performance characteristics: No. 106, Reed Unit Air Filters; No. 114, Reed Streamline Air Filter; No. 117, Reed Multi-Panel Air Filter. Our Engineering Department will gladly cooperate in the solution of Air-Cleaning and Dust-Control problems.

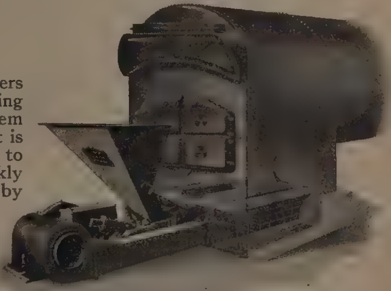
Detroit Stoker Company

Third Floor General Motors Building

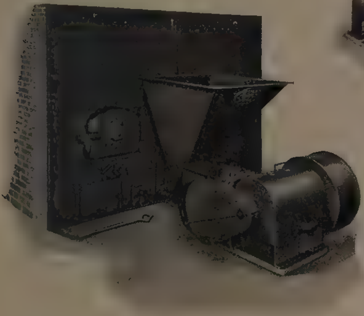
Detroit **Michigan**

DETROIT JUNIOR STOKER

Especially adapted to small heating boilers of all types. The small electric driving motor, the fan and the fuel plunger system are combined into one unit. The draft is automatically regulated in proportion to the fuel burned. Steam is raised quickly as both fan and fuel feed are started by closing a switch.



For Internally Fired Boilers



For Brick-set Boilers

Advantages include:

1. **Plunger Feed** method of introducing fuel.
2. **Control** of quantity and distribution of fuel.
3. **Deep Retort** provides high fuel capacity.
4. **Mechanical Ash Dump**—ashes dropped in pits and cooled—no smoke or dust in boiler room.
5. **Sturdy Mechanical Drive**—tapered thrust roller bearings reduce power consumption.
6. **Variable Speed Motors** for either A. C. or D. C. current.

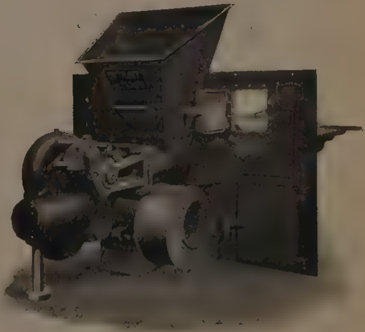
Ask for Bulletin **369.**

DETROIT UNISTOKER

Compact, self-contained Single Retort motor-driven (or driven by individual steam turbine), with motor and blower mounted on front of stoker. Each boiler and stoker a complete independent unit. Separate and individual control of stroke of both ram and pusher bar governs quantity of fuel admitted and its distribution. Ask for Bulletin **669.**

Stokers For Large Boilers

A Detroit Stoker for every service—from the smallest to the largest boilers. For descriptive matter on stokers for large boilers. Ask for Bulletin **969.**



Detroit UniStoker

Iron Fireman Manufacturing Company

MANUFACTURERS OF AUTOMATIC COAL BURNERS

Portland, Oregon

Branch Offices

CLEVELAND, OHIO — NEW YORK, N. Y. — ST. LOUIS, MO.

IRON FIREMAN Automatic Coal Burners

"Forced Underfiring" Principle

Iron Fireman "Forced Underfiring" is based on the scientifically correct principle of feeding fuel to the fire from below, under forced draft.

Conveyed from the hopper by a feed worm, coal enters the firebox under the fire and is gradually forced upward into the firebed. As the coal approaches the fire, it is gradually heated to the proper temperature for complete combustion. The volatile gases are distilled off in the presence of an excess of oxygen, and as they pass upward through the incandescent firebed they are completely consumed. The ash is fused into clinkers which are easily removed.

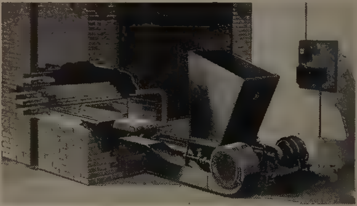
Iron Fireman "Forced Underfiring" frequently produces firebox temperatures 500 to 1,000 deg. hotter than hand firing, as actual tests from many installations show.

Installation

The Iron Fireman is made in sizes to fit any plant from 5 up to 200 Boiler H.P., and also home furnaces. It can be installed quickly in practically any solid fuel boiler or furnace, old or new. If necessary, the installation can be made with practically no interruption of the service.

Machines are shipped complete from the factory. All parts are standard and interchangeable.

Iron Fireman in operation. Installed under horizontal return tubular boiler. Low bridge wall. "Hot blast furnace" fire. Iron Fireman can be installed in practically any type of boiler or furnace



Cutaway view, showing details of typical Iron Fireman installation

Features of Design

Operation of the Iron Fireman is characterized by simplicity throughout.

Diaphragmatic air intake control governs application of forced draft. Cast iron sectional dead plates and tuyere blocks are air cooled. Soft steel sheer pin eliminates possibility of burning out motor or damaging parts.

Continuous Worm Feed Principle

The Iron Fireman transmission (gear case), which drives the feed worm, has three distinct speed ratios, each one continuous. No plungers or ratchets are used.

The continuous feed gradually and evenly conveys the coal into the retort, making ideal distribution of coal in the firebox and producing a fire with the minimum of agitation. The coal and all volatile gases are thus burned, so that a maximum of heat is obtained without smoke.

Iron Fireman Feed Worm

Sizes and Capacities

MODEL	De Luxe	Junior	No. 2	No. 3	No. 4	No. 4A	No. 5	No. 5A
Length overall.....................inches	73	73	81	87	114	125	140	140
Maximum projections outside boiler....inches	40	40	45	46	65	70	81	81
Hopper capacity....................cu. ft.	5	5	7	7	13½	13½	17	17
Coal feed per hour (maximum)...........lb.	40	60	100	200	300	500	750	1,000
*Coal feed per hour (minimum)...........lb.	28	20	33	67	100	167	250	335
Capacity steam radiation.............sq. ft.	800	1,200	2,000	4,000	6,000	10,000	15,000	20,000
Capacity hot water radiation..........sq. ft.	960	1,440	2,700	5,300	8,000	13,300	20,000	26,600

NOTE.—Coal consumption based on 5 lb. of coal to the boiler horsepower per hour.
*Minimum feed per hour based on continuous operation of Iron Fireman.

Transmission

The Transmission (Gear Case), is built to precision standards which result in noiseless operation and long life. All gears and pinions are drop-forged from special alloy steels. Nine measurements held within tolerance of .005 in.; fourteen within .001; sixteen within .002; twenty-one within .005, and twelve within .01 in.

Iron Fireman gear case

Automatic Controls

Automatic controls start and stop the Iron Fireman. They are made for every type of plant—proper units are supplied with each installation.

Two types of pressure regulators are standard; one for steam boilers of any pressure and one for low pressure and vacuum systems. A hot water control is used for hot water boilers. The clock or plain thermostat controls the temperature of residence or building. The furnace regulator provides for desired maximum temperature of the firebox.

Pressure Regulator

Economical Operation

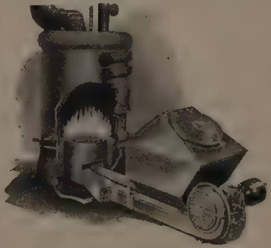
Iron Fireman makes fuel economy by burning low price, slack coal, and less of it. Labor is reduced to the minimum—the only duty of the fireman is to fill the hopper occasionally and remove clinkers when necessary.

Iron Fireman users report savings from 15 to 50 per cent on fuel costs alone.

Iron Fireman for Homes

The Iron Fireman DeLuxe model for homes can be installed quickly in practically any kind of a home furnace—steam, hot water, vacuum or warm air. It employs "Forced Underfiring" principle of operation, the same as the larger machines.

The Iron Fireman clock thermostat automatically regulates the room temperature, bringing it up to the desired day temperature in the morning and lowering it to the night level. Furnace controls govern the temperature of the firebox.


Iron Fireman installed in a domestic boiler

Engineering Service

The Iron Fireman organization is nationwide. Trained men, backed by one of the largest organizations in the field, are at your service to help you with practical power plant and heating information.

Any Iron Fireman engineer will gladly submit complete information to you.

Catalog and Information

Send for the Iron Fireman catalog and descriptive folder which gives special data about installations in particular types of industries and in homes. Secure them by addressing the factory or any Iron Fireman representative.

Iron Fireman Manufacturing Co.
Portland, Oregon

Whiting Corporation

HARRINGTON DIVISION

Harvey, Illinois

Manufacturers of the Whiting Automatic Stoker for Heating and Power Plant Boilers of 25 to 250 HP.

The Whiting Stoker (formerly the King Coal) is a front, horizontal feed, stepped grate mechanism, having two stationary and two movable sections. Gravity plays no part in the horizontal progression of the fuel bed. It provides fully automatic stoking for small boilers, discharging the ash as well as feeding the fuel.

Hospitals, hotels, apartments, schools and laundries and all sizable buildings find its smokeless combustion, fuel saving and fully automatic operation of substantial value in reducing their heating costs.

Fits any Boiler—The Whiting Stoker can be built to exactly fit any type of boiler of 25 to 250 hp. and installed with but few or no changes. It requires a minimum of setting height, making possible larger combustion space with greater efficiency and ability to carry overloads. Sixty-two sizes are available, all identical in construction.

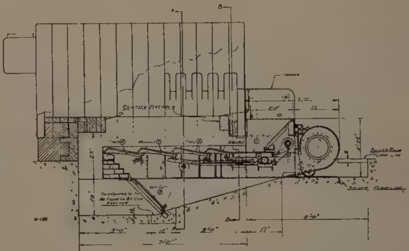
Smokeless Operation with any grade of fuel has made the Whiting Stoker the solution of the smoke problem of hundreds of buildings.

Flexibility—Varying speed of travel and depth of coal bed are secured by one to four inch adjustability of the stroke and the adjustability of the hopper gate. Only alternate grates are movable, thus securing uniform flow of coal without caking. An even fire is maintained continuously.

Combustion is progressive and complete. We guarantee 12 per cent CO_2.

Burns all Grades of Fuel, including Mid-Western screenings without smoke and with high efficiency, resulting in substantial reductions in fuel costs.

Continuous and Automatic Ash Discharge is an exclusive feature of the Whiting Stoker which is entirely self cleaning.



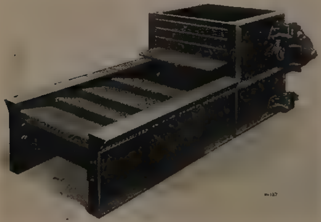
1. *Feed plate and first step of grate (movable).*
2. *Second step of grate (stationary).*
3. *Third step of grate (moves synchronously with step No. 1).*
4. *Fourth step of grate (stationary).*
5. *Cast iron door in ash pit (also provides seal for wind box).*

Standard Sizes

Grate Widths in feet: 2, 2½, 3, 3½, 4, 4½, 5, 5½, 6.

Grate Lengths in feet: 3½, 3¾, 4¼, 4½, 5, 5¼, 5¾, 6.

Each width can be made in any length specified above. Required furnace width 9 in. more than the grate width. Active grate area 10 in. shorter than maximum depth of furnace.



Whiting Stoker (Patented)

American Radiator Company

IDEAL GAS BOILERS

Distributor

American Gas Products Corporation

376 Lafayette Street, New York

IDEAL GAS BOILERS

Completely up-to-date, Ideal Gas Boilers represent best practice in gas boiler construction and in automatic controls. They are built for all Steam, Vapor and Hot Water heating systems as well as Hot Water Supply.

Ideal Gas Boilers are available now with either throttling or snap action control valves. Either valve is available with motor control. The motor control is a motor mounted directly on the valve and operates the valve mechanically.

Especial attention is called to the convenience and simplicity of Motor Equipment which requires the addition of a thermostat only to obtain room temperature control.

Thermostatic pilots are all of the Vapor-Tension type which require no adjusting after once being properly set.

The controls are all mechanical in operation and are all centered in one main supply control valve.

Ideal Gas Boiler, Type 1-G

The Ideal Gas Boilers listed below comply with all the American Gas Association approval requirements and have been approved by the A. G. A. Laboratories. Four other larger units are available. Information furnished on request.

RATINGS—DIMENSIONS

Steam Boiler No.	A.G.A. Steam Rating, Sq. Ft.	Supplies, Sq. Ft. of Direct Cast Iron Radiation	Water Boiler No.	A.G.A. Water Rating, Sq. Ft.	Supplies, Sq. Ft. of Direct Cast Iron Radiation	Output, B.t.u.	Boiler Horsepower	Number of Sections	Number of Burners	Number and Size of Gas Control Valve, Inches	*Number and Size of Tappings		Number and Size of Flue Connections, Diam., Inches	Dimensions		
											Supply Inches	Return Inches		Height Including Diverter, Inches	Width, Inches	Depth, Inches
0-GS-4	270	173	0-GW-4	430	280	64,000	1.9	4	3	1-1	1-2½	1-2½	1-5	54	18½	13¾
0-GS-5	340	219	0-GW-5	540	350	81,000	2.4	5	3	1-1	1-2½	1-2½	1-5	54	18½	16¾
0-GS-6	410	263	0-GW-6	660	420	98,200	2.9	6	3	1-1	1-2½	1-2½	1-6	55	18½	19¾
0-GS-7	480	307	0-GW-7	770	490	115,200	3.4	7	3	1-1	1-2½	1-2½	1-6	55	18½	22¾
1-GS-4	550	353	1-GW-4	880	564	132,000	3.9	4	3	1-1¼	2-4	2-4	1-6	52½	18½	24¾
1-GS-5	710	456	1-GW-5	1130	732	170,000	5.1	5	4	1-1¼	2-4	2-4	1-7	52½	22½	24¾
1-GS-6	870	558	1-GW-6	1390	909	208,000	6.2	6	5	1-1½	2-4	2-4	1-8	53	26½	24¾
1-GS-7	1030	661	1-GW-7	1640	1076	246,000	7.3	7	6	1-1½	2-4	2-4	1-8	53¾	30½	24¾
1-GS-8	1180	767	1-GW-8	1890	1254	284,000	8.5	8	7	1-1½†	2-4	2-4	1-8	54½	34½	24¾
1-GS-9	1340	872	1-GW-9	2150	1440	322,000	9.6	9	8	1-2	2-4	2-4	1-9	57½	38½	24¾
1-GS-10	1500	981	1-GW-10	2400	1624	360,000	10.7	10	9	1-2	2-4	2-4	1-9	58¼	42½	24¾
1-GS-11	1660	1090	1-GW-11	2650	1810	398,000	11.9	11	10	1-2	2-4	2-4	1-10	58¾	46½	24¾
4-GS-6	2000	1332	4-GW-6	3200	2214	480,000	14.3	6	5	1-2	1-6	1-5	1-11	69	27	41½
4-GS-7	2400	1624	4-GW-7	3840	2676	576,000	17.2	7	6	1-2†	1-6	1-5	1-12	69¾	31	41½
4-GS-8	2800	1922	4-GW-8	4480	3151	672,000	20.0	8	7	1-2†	1-6	1-5	1-13	71¾	35	41½
4-GS-9	3200	2215	4-GW-9	5120	3634	768,000	22.9	9	8	1-2½	1-6	1-5	1-14	72½	39	41½
4-GS-10	3600	2506	4-GW-10	5760	4114	864,000	25.8	10	9	1-2½	1-6	1-5	1-15	75	43	41½
4-GS-11	4000	2800	4-GW-11	6400	4571	960,000	28.6	11	10	1-2½	1-6	1-5	1-16	75¾	47	41½
4-GS-13	4800	3400	4-GW-13	7680	5500	1,152,000	34.4	13	12	1-3	2-6	1-5	2-12	69¾	61	41½
4-GS-15	5600	4000	4-GW-15	8960	6400	1,344,000	40.0	15	14	1-3	2-6	1-5	2-13	71¾	69	41½
4-GS-17	6400	4600	4-GW-17	10240	7300	1,536,000	45.8	17	16	2-2½	2-6	1-5	2-14	72½	77	41½
4-GS-19	7200	5100	4-GW-19	11520	8240	1,728,000	51.6	19	18	2 2½	2-6	1-5	2-15	75	85	41½
4-GS-21	8000	5700	4-GW-21	12800	9100	1,920,000	57.2	21	20	2-2½	2-6	1-5	2-16	75¾	93	41½
4-GS-22	8400	6000	4-GW-22	13440	9600	2,016,000	60.0	22	21	2-3	4-6	2-5	3-13	71¾	103	41½
4-GS-25	9600	6900	4-GW-25	15360	11000	2,304,000	68.7	25	24	2-3	4-6	2-5	3-14	72½	115	41½
4-GS-28	10800	7700	4-GW-28	17280	12300	2,592,000	77.4	28	27	2-3	4-6	2-5	3-15	75	127	41½

*Additional tappings available by removing plugs and jacket cover plates, 4-G-6 to 4-G-11 = 1–6 in. supply and 1–5 in. return; 4-G-13 to 4-G-28 = 2–6 in. supply and 2–5 in. return. †Governor one pipe size larger. Water line: Type 0-G = 32 in.; Type 1G = 30 in.; Type 4-G = 43 in.

The Bryant Heater & Mfg. Company

Manufacturers of Bryant Tubular Gas Boilers, Bryant Warm Air Furnaces, Bryant Automatic Hot Water Storage Heaters

17850 St. Clair Avenue, **Cleveland, Ohio**

Branches in All Principal Cities

TUBULAR
TRADE MARK
REGISTERED

BRYANT AUTOMATIC HOT WATER STORAGE HEATERS

(See Bryant Warm Air Furnaces and Boilers)

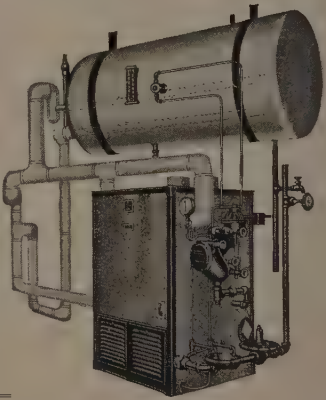
The Indirect Storage System:

For Small or Large volume water heating, this type of system is particularly adaptable.

For Hard Water this indirect system is unsurpassed. The water in the storage tank, which may have sediment or lime in it, does not pass through the tubes of the boiler, thus making the life unlimited.

Sediment or Lime in the hot water will settle out in the tank where the temperature is comparatively low and whence it is easily removed through the hand hole.

Where High Water Pressures are encountered (above 70 lb. per sq. in.) this type of system should always be used.

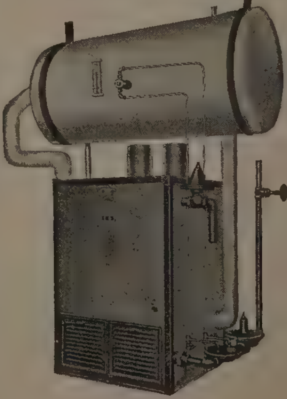


GUARANTEED RATINGS AND CAPACITIES OF BRYANT TUBULAR BOILERS

Boiler No.	Available B.t.u. per Hour (Output)	Boiler Horse Power	Capacity in Gallons per Hour Raised (deg. fahr.)							
			10	20	40	60	80	100	120	140
Model 2 Boilers										
3–2	51,750	1.60	600	300	155	105	80	60	50	45
4–2	69,000	2.10	800	400	205	140	105	80	70	60
5–2	86,250	2.60	1050	525	260	170	130	105	85	75
6–2	103,500	3.10	1250	625	310	205	155	125	105	90
Model 43 Boilers										
3–4	133,200	4.00	1600	800	400	270	200	160	135	115
4–4	177,600	5.30	2150	1075	535	355	270	215	180	155
5–4	222,000	6.60	2700	1350	670	445	335	270	225	190
6–4	266,400	8.00	3200	1600	805	535	400	320	270	230
7–4	310,800	9.30	3750	1875	935	625	470	375	310	270
8–4	355,200	10.60	4300	2150	1070	715	535	430	355	305
9–4	399,600	11.90	4800	2400	1205	805	600	480	400	345
10–4	444,000	13.20	5350	2675	1340	890	670	535	445	380
11–4	488,400	14.60	5900	2950	1470	980	735	590	490	420
12–4	532,800	15.90	6400	3200	1605	1070	805	640	535	460
13–4	577,200	17.20	6950	3475	1740	1160	870	695	580	500
Model 6 Boilers										
6–6	532,800	15.90	6420	3210	1605	1070	805	645	535	460
8–6	710,400	21.20	8560	4280	2140	1430	1070	855	715	615
10–6	888,000	26.50	10700	5350	2675	1785	1340	1070	890	765
12–6	1,065,600	31.80	12840	6420	3210	2140	1610	1285	1070	920
14–6	1,243,200	37.10	14980	7490	3745	2500	1875	1500	1250	1070
16–6	1,420,800	42.40	17120	8560	4280	2855	2145	1710	1425	1225
18–6	1,598,400	47.70	19260	9630	4815	3215	2410	1925	1605	1380
22–6	1,953,600	58.30	23540	11770	5885	3925	2950	2355	1960	1685
26–6	2,308,800	68.90	27820	13910	6950	4640	3485	2780	2315	1990

The Direct Storage System:

The Direct System may be used in installations where soft water is available and where water pressures are below 70 lb. per sq. in.



The Bryant Heater & Mfg. Company

Manufacturers of Bryant Tubular Gas Boilers,
Bryant Warm Air Furnaces, Bryant Automatic
Hot Water Storage Heaters

17850 St. Clair Avenue, **Cleveland, Ohio**

Branches in All Principal Cities

TUBULAR
TRADE MARK

BRYANT TUBULAR GAS BOILERS

(See Bryant Warm Air Furnaces and Automatic Hot Water Storage Systems)

Bryant Tubular Gas Boilers cover the entire range of building-heating requirements. To accomplish this in the most economical and efficient manner, four lines of boilers have been developed, the Model 2 (4 sizes); Models 43 and 45 (11 sizes), and the Model 6 (9 sizes).

Bryant Boilers can be used with any type of steam, vapor or hot water heating system or for the generation of low pressure steam for **Industrial Work.**

Rating. The Gas Boiler rating is the boiler output measured in terms of square feet of Direct Cast Iron Radiation. The Gas Boiler rating is secured by dividing the available heat units per hour by 240 for steam boilers and by 150 for water boilers. These ratings apply to any type gas.

Model 2

Model 45

Model 6

Boiler No.	Available B.t.u. per Hour (Output)	Boiler Horse Power	Gas Boiler Rating	
			Steam	Water
3–2	51,750	1.60	210	345
4–2	69,000	2.10	280	460
5–2	86,250	2.60	350	575
6–2	103,500	3.10	420	690
3–4	133,200	4.00	560	890
4–4	177,600	5.30	740	1190
5–4	222,000	6.60	930	1480
6–4	266,400	8.00	1110	1780
7–4	310,800	9.30	1300	2070
8–4	355,200	10.60	1480	2370
9–4	399,600	11.90	1670	2660
10–4	444,000	13.20	1850	2960
11–4	488,400	14.60	2040	3260
12–4	532,800	15.90	2220	3550
13–4	577,200	17.20	2410	3850
6–6	532,800	15.90	2220	3550
8–6	710,400	21.20	2960	4740
10–6	888,000	26.50	3700	5920
12–6	1,065,600	31.80	4440	7100
14–6	1,243,200	37.10	5180	8290
16–6	1,420,800	42.40	5920	9470
18–6	1,598,400	47.70	6660	10660
22–6	1,953,600	58.30	8140	13020
26–6	2,308,800	68.90	9620	15390

Send for catalog to obtain more detailed information and specifications.

The Bryant Heater & Mfg. Company

**Manufacturers of Bryant Tubular Gas Boilers,
Bryant Warm Air Furnaces, Bryant Automatic
Hot Water Storage Heaters**

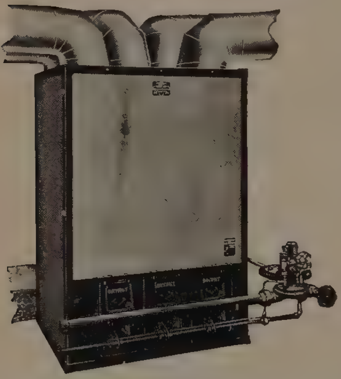
17850 St. Clair Avenue, **Cleveland, Ohio**

Branches in All Principal Cities

TUBULAR
TRADE MARK
REGISTERED

BRYANT WARM AIR FURNACES

(See Bryant Tubular Gas Boilers and Automatic Hot Water Storage Systems)



Construction—The Bryant Gas-Fired Warm Air Furnaces are available in six different sizes, ranging in capacity from 70,000 B.t.u. to 246,400 available B.t.u. per hour. Each burner is enclosed in a "waved" designed **cast-iron section,** providing a long, **durable** passageway for the products of combustion to the flue. The embodiment of fins on the outer surface of all sections adds greatly to their heat-absorbing quality. The burners are correctly designed with raised and drilled ports. The exclusive Bryant Nonoys feature is incorporated in these burners to insure quietness of operation. The warm air outlet and the cold air inlet are of sufficient area to produce mild and healthful register temperatures. The metal jacketed cover is finished with a handsome and enduring baked crystalline enamel.

Operation—The automatic operation of a Bryant Gas-Fired Furnaced is assured by the use of the Bryant gas-actuated system of control. The main supply of gas to the burners is controlled by a Room Temperature Thermostat. High operating efficiency is obtained even under partial loads as each section has an individual burner.

Installation—We recommend that installations be made as put forth in Section VI of the Code of Minimum Requirements for the Heating and Ventilation of Buildings.

Combustion—Complete combustion of the gas is obtained with the Venturi type Nonoys burner. This high efficiency is assured because the burner adjustment will remain the same with the constant gas pressure provided by the Bryant Gas Pressure Regulator.

Controls—The simple and durable Bryant gas-actuated controls utilize the unfailing force of gravity and the laws of the expansion of metal in their operation. Thermostatic pilots are standard equipment. A gas-actuated limit control, which provides a positive and complete shut-off of the gas when high bonnet temperatures are reached, is available on any size Bryant furnace. The furnaces may be had either with or without automatic humidification.

Temperature Regulation—The Bryant Solenoid Valve is provided for use with a Room Temperature Thermostat, thus eliminating the necessity of an electric motor to operate the main gas control valve. Steady, even temperatures are maintained in the room by having fully 15,000 B.t.u. per 35,000 B.t.u. rating, stored in the furnace and available to induce gravity flow of air in the system after the gas is turned off. Under normal operation this sensible heat will keep the air circulating through the system and thus prevent the stratification of the air in the room during the period the furnace is turned off.

Air Circulation—The Bryant Warm Air Furnace is designed to opeate with a **gravity** or **forced air system.** If the forced air system is used, it is preferable to have the installation of the ducting and the type of fan such that the system will deliver heat in spite of an electrical outage. In this way the owner is not entirely dependent upon the successful operation of the fan motor for the comfort and convenience of gas heating.

L. J. Mueller Furnace Co.

ESTABLISHED 1857

200 Reed Street, **Milwaukee, Wis.**

Gas-Era Boiler

Gas-Era Gas-Fired Boilers

Adaptable for steam or hot water heating. Completely automatic operation. Cast iron construction for durability, with asbestos-lined metallic jacket. Vertical burner adjustment permits use with any manufactured or natural gas. Have steady water line and will not prime. Interior surfaces may be thoroughly cleaned without disturbing jacket. Multiple unit construction permits increase in size when desired. Boiler is highly efficient, securing maximum heat utilization with minimum gas consumption.

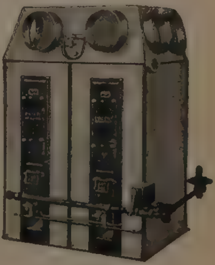
HOT WATER		STEAM		Floor Space Inches	Vents		Gas Valve Size, Inches	
Boiler No.	*A.G.A.* Rating	Boiler No.	*A.G.A.* Rating		Number	Diameter Inches	Manufactured Gas	Natural Gas
13–W	670	13–S	420	31¼ x 46½	1	4	1	1
25–W	1,340	25–S	840	39 x 47⅞	1	7	1¼	1¼
37–W	2,010	37–S	1,260	46¾ x 51⅞	1	9	1½	1¼
49–W	2,680	49–S	1,680	54½ x 53⅝	1	10	1½	1¼
511–W	3,350	511–S	2,100	62¼ x 54¾	1	11	1½	1½
613–W	4,020	613–S	2,520	70 x 51⅝	2	9	1½	1½
715–W	4,690	715–S	2,940	79¾ x 53⅝	2	10	2	1½
817–W	5,360	817–S	3,360	87½ x 53⅝	2	10	2	2
919–W	6,030	919–S	3,780	95¼ x 54¾	2	11	2	2
1021–W	6,700	1021–S	4,200	103 x 54¾	2	11	2	2
1123–W	7,370	1123–S	4,620	110¾ x 56⅛	2	12	2	2
1225–W	8,040	1225–S	5,040	120½ x 53⅝	3	10	2½	2
1327–W	8,710	1327–S	5,460	128¼ x 54¾	3	11	2½	2
1429–W	9,380	1429–S	5,880	136 x 54¾	3	11	2½	2
1531–W	10,050	1531–S	6,300	143¾ x 54¾	3	11	2½	2
1634–W	10,720	1634–S	6,720	87½ x 107¼	2	14	2½	2
1838–W	12,060	1838–S	7,560	95¼ x 109½	2	16	3	2½
2042–W	13,400	2042–S	8,400	103 x 109½	2	16	3	2½
2246–W	14,740	2246–S	9,240	110¾ x 112¼	2	17	3	2½
2450–W	16,080	2450–S	10,080	120½ x 107¼	3	14	3½	3
2654–W	17,420	2654–S	10,920	128¼ x 109½	3	16	3½	3
2858–W	18,760	2858–S	11,760	136 x 109½	3	16	3½	3
3062–W	20,100	3062–S	12,600	143¾ x 109½	3	16	3½	3

Gas-Era Gas-Fired Warm Air Furnace

Cast iron construction, with lacquered casing in attractive color. Completely automatic, tamper-proof operation. Burns any gas, natural or manufactured. Accessible for cleaning. Ample free area. Automatic moisture supply. Adaptable for forced air heating on large jobs. Multiple unit construction.

Furnace No.	*A.G.A.* Input Rating B.t.u per Hour	Total Load B.t.u per Hour	Capacity Warm Air Pipes Sq. In.
1 (10)*	65,000	47,500	430
2 (20)	130,000	95,000	860
3 (30)	195,000	142,500	1290
4 (40)	260,000	190,000	1720
5 (50)	325,000	237,500	2150
6 (60)	390,000	285,000	2580

*Same furnace, less electrical equipment and automatic humidifier. Data on larger units on application.



Gas-Era Furnace

Gas-Era Furnaces and Boilers tested and approved for all sizes by American Gas Association

The Pittsburg Water Heater Company

Manufacturers of

Gas-Fired House-Heating Boilers and Automatic Gas Water Heaters

Pittsburgh, Pa.

Offices in All Principal Cities

Pittsburg Gas-Fired House-Heating Boilers

The Pittsburg is a gas-fired house-heating boiler, designed for either hot water, steam or vapor heating, and made in various sizes ranging from 375 to 8,125 sq. ft. of steam radiation and 600 to 13,000 sq. ft. of water radiation. These boilers cover a range of from 2.7 to 57.9 hp. Approximate weight from 565 lbs. to 8,985 lbs.

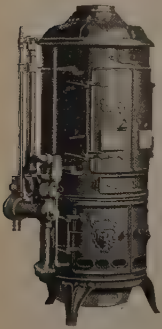
Water Tubes—An outstanding feature of the "Pittsburg" is the design and arrangement of the water tubes. They are triangular in shape and so arranged as to afford direct heat travel through the boiler, with maximum heat absorption.

Burners—Are of cast iron, running from front to rear. A Venturi Mixing Tube and Air Mixer are part of burner and conform to recommendation of U. S. Bureau of Standards. All burners are readily accessible through the hinged door in base and can be removed or inserted with ease.

Water-Jacketed Sides—Water circulates through jacketed sides and absorbs heat; no heat being wasted.

Insulated Jacket—These boilers are equipped with an insulated jacket covering entire walls of boiler. Jacket is of metal, Duco finish, lined with asbestos insulating material. Front of Jacket Cover can be removed easily. Vertical cast iron panels in front of boiler can be removed, opening the boiler for inspection and cleaning. Boiler is easily cleaned.

Pittsburg Automatic Gas Water Heaters



Twenty-two sizes of Pittsburg Water Heaters are available—a size and style for every building and for every hot water demand—from the smallest automatic heater to the largest Multi-Coil Storage System.

The Instantaneous heaters range in capacities from 2 to 10 gallons of hot water a minute.

The Storage heaters range in tank capacities from 20 to 66 gallons in the unit types, and from 66 gallons to almost any amount in the Multi-Coil type.

Pittsburg Storage Tanks (iron)—250-lb. cold water test and 125-lb. working pressure—are guaranteed for two years, except when used with water containing acids. They are furnished in handhole or manhole type, with capacities of from 80 to 1,000 gallons, weighing from 290 to 3,300 lbs. Special sizes to order.

The Multi-Coil Heater is used in large residences, apartment buildings, office buildings, hospitals, public garages, factories, public institutions, schools, bath houses, swimming pools, hotels and restaurants, where hot water is required in quantities from 100 to 5,000 gallons per hour.

AMERICAN RADIATOR COMPANY

40 West 40th Street, **New York City**

Manufacturers of Ideal Boilers, American Radiators and other Products for Heating, Ventilating and Refrigerating

A specimen table of **Ideal Boiler** performance data, as given in the new *Ideal Fitter*, is shown on page 561. So comprehensive is this new data that condensing for inclusion in THE GUIDE has been found impractical. Complete descriptions, measurements, and data may be found in the *Fitter*.

IDEAL REDFLASH BOILERS

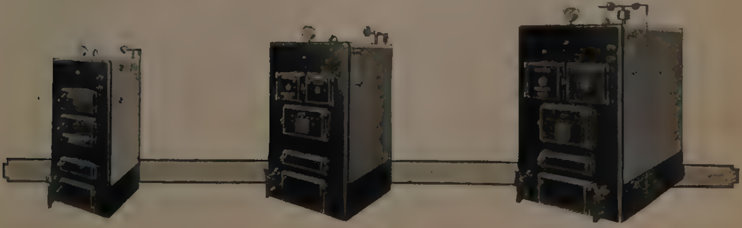
For All Fuels

The Ideal Redflash Boiler is a completely equipped, sectional, jacketed boiler, in sizes to fit a large range of homes and other buildings. In it are incorporated the principles of design which have been developed during forty years of manufacturing experience and research.

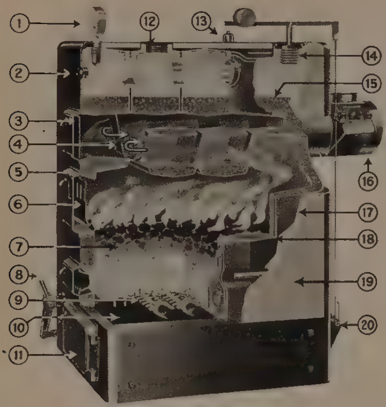
The Redflash Boiler is enclosed in an indestructible, enameled, steel jacket which permanently protects a multi-ply lining of asbestocel insulation.

The baked enamel finish of the jacket makes it easy to dust and clean. All contacting surfaces have been machined to prevent leakage.

All Ideal Redflash Steam Boilers and Nos. 1 and 2 Series Ideal Redflash Water Boilers are completely equipped with accessories including the sensitive and reliable Arco Automatic Regulator. Nos. 3, 4 and 5 Series Ideal Redflash Water Boilers are equipped with hand regulation.



No. 1 Series *No. 2 Series* *No. 3 Series*



Specifications

1—Steam Gauge.

2—Blow-off tapping.

3—Flue door with curved baffle lining, insures easy gas travel.

4—Long, flue travel secures high operating economy.

5—All contacting surfaces of doors and sections are machine ground.

6—Sturdy fire door with special baffle lining containing secondary air distributor.

7—Large fuel chamber.

8—Shaking mechanism, easily operated, durable.

9—Grates permit use of small size coal. Special grates for burning buckwheat are obtainable on special order for Nos. 3, 4 and 5 Series.

10—Ashpit of ample proportions for easy caretaking and safeguarding of grates.

11—Substantial doors and plate fittings.

12—Flow tapping.

13—Relief Valve.

14—Sensitive Arco Automatic Regulation.

15—Large steam dome and disengaging surface.

16—Two-way smokehood with check and choke dampers.

17—One-inch asbestocel insulation.

18—Seepage-proof construction between sections.

19—Sheet steel jacket with baked enamel finish.

20—Primary draft damper.

Tapped for Excelso Water Heater

No. 4 Series

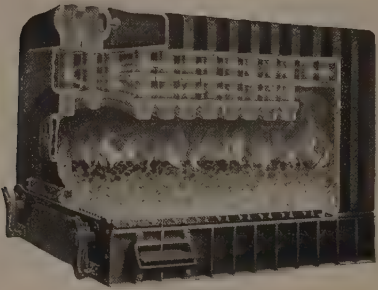
No. 5 Series

No. 3 IDEAL REDFLASH BOILER—Performance Data—Steam and Water

Number of Boiler	Output in Equivalent Direct Radiation Sq. Ft. Steam (240 B.t.u.)....... Water (150 B.t.u.).......	1500 2400	1750 2800	2000 3200	2250 3600	2500 4000	2750 4400	3000 4800	3250 5200	3500 5600	3750 6000	4000 6400	4250 6800	4500 7200	4750 7600	5000 8000	5250 8400	5500 8800	5750 9200	6000 9600
	Output in (1000's) B.t.u. per Hr.	360	420	480	540	600	660	720	780	840	900	960	1020	1080	1140	1200	1260	1320	1380	1440
3-S-12 3-W-12	Time Available Fuel Will Last..........Hours*	....	....	18.7	16.4	14.7	13.2	12.0	11.0	10.1	9.4	8.7	8.1	7.5	7.1	6.6	6.2	5.9	....	....
	Overall Efficiency of Boiler, ...Per Cent	....	....	72.8	72.2	71.6	71.0	70.4	69.8	69.2	68.6	67.9	67.2	66.4	65.6	64.7	63.8	62.9	....	....
Grate Area 14.75 sq. ft.	Stack Gas Temperature, ...Deg. Fahr.	....	....	450	485	520	555	590	625	660	695	730	765	800	835	870	905	940	....	....
Fuel Capacity 1310 lb.	Fuel Burned per Sq. Ft. of Grate per Hr....Pounds	....	....	3.6	4.1	4.5	5.0	5.5	6.1	6.6	7.1	7.7	8.2	8.9	9.4	10.1	10.7	11.3	....	....
	Draft Required, ...Inches of Water	....	....	0.04	0.05	0.05	0.06	0.07	0.08	0.09	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.22	....	....
Available Fuel 983 lb.	Chimney Size.....Inches	....	....	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	....	....
	Chimney Height....Feet	....	....	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	....	....
3-S-13 3-W-13	Time Available Fuel Will Last..........Hours*	....	....	20.5	18.1	16.2	14.6	13.3	12.2	11.2	10.4	9.7	9.0	8.4	7.9	7.4	7.0	6.6	6.2	5.9
	Overall Efficiency of Boiler, ...Per Cent	....	....	73.4	72.9	72.4	71.9	71.3	70.8	70.3	69.8	69.2	68.6	67.9	67.2	66.5	65.7	64.9	64.0	63.2
Grate Area 16.10 sq. ft.	Stack Gas Temperature, ...Deg. Fahr.	....	....	430	460	490	525	555	590	630	660	695	725	760	790	820	855	885	920	950
Fuel Capacity 1430 lb.	Fuel Burned per Sq. Ft. of Grate per Hr....Pounds	...	....	3.3	3.7	4.1	4.6	5.0	5.5	5.9	6.4	6.9	7.4	7.9	8.4	9.0	9.5	10.1	10.7	11.3
	Draft Required, ...Inches of Water	....	....	0.04	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.12	0 14	0.15	0.17	0.19	0.21	0.23	0.25
Available Fuel 1073 lb.	Chimney Size.....Inches	....	....	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20	20x20
	Chimney Height..Feet ..	....	....	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65

*Based on fuel of 12,500 B.t.u. per lb. For economical operation, add piping tax to Direct Radiation Load (Equivalent Direct Radiation); then select boiler from figures enclosed by heavy lines.

IDEAL WATER TUBE BOILER



Sectional View of 36-Inch Boiler

An extensive series of water-backed, vertical tubes divide the body of water in the **Ideal Water Tube Boiler** into many thin streams, and expose an unusually large amount of heat-absorbing surface. This design, united with the other features of the boiler—the balanced proportions of grate area, direct heating surface, flue area, and gas travel unite in accomplishing quick, economical and durable heating service with the minimum amount of attention.

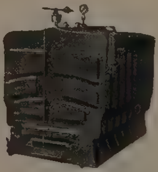
The sectional construction of **Ideal Water Tube Boilers** allow them to be placed conveniently in new or old buildings without tearing down walls or ripping up floors.

Installed in battery, these boilers are admirably adapted to serve the needs of large buildings.

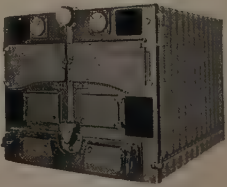
Tapped for Excelso Water Heater

23-29-Inch

36-Inch

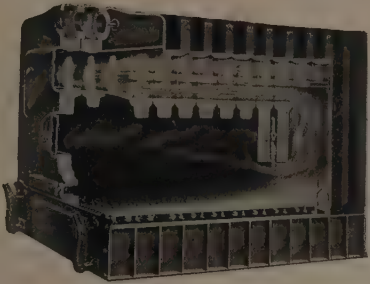


48-Inch



79-Inch

IDEAL SMOKELESS BOILER



Sectional View of 36-Inch Boiler

Simple in its operation, requiring no special degree of skilled attention, the **Ideal Smokeless Boiler** burns all grades of soft coal smokelessly and economically. It complies with the most rigid city smoke ordinances.

This boiler accomplishes its high record of smokeless performance through its special, patented device, the Ideal Smoke Oxidizer. It inducts and distributes fresh air in fine uniform streams over a bed of glowing coal, where it mixes with the volatile matter. This mixture ignites and burns at an exceedingly high temperature, consuming, within the boiler, the smoke-producing particles of carbon. In this way the smoke nuisance is eliminated and a larger amount of the heat value of the smoke is utilized.

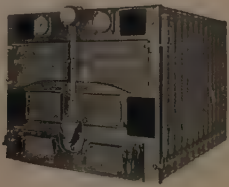
The Ideal Smoke Oxidizer is an integral part of the boiler. It eliminates the need of brick linings and other accessories. Being water-backed throughout, it cannot burn out.

Tapped for Excelso Water Heater on Order

29-inch

36-Inch

48-Inch



79-Inch

IDEAL ARCO ROUND BOILER

Steam Boiler

Water Boiler

Many years of satisfactory service in hundreds of thousands of installations has earned for the **Ideal Arco Round Boiler** an outstanding reputation.

To the owner it means quick heat generation, dependable lifetime service, and a high degree of operating economy with a minimum of care.

Special Features

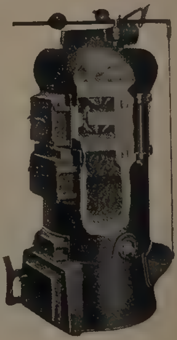
1—Broad and high steam dome provides large steam disengaging area and ample storage space.

2—Grate area, direct heating surface, and gas travel designed for quick heating and fuel economy.

3—Contacting surfaces of doors and dampers are machine ground to form tight, leak-proof construction.

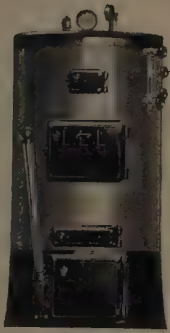
4—Doors, frames, hinge pins of substantial construction.

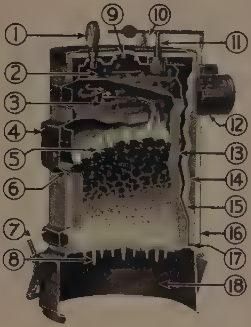
5—Convenient Rear Draft Control.



Tapped for Excelso Water Heater

IDEAL ARCOFLASH BOILER





The Ideal Arcoflash Boiler is especially designed for 5 to 8 room homes, meeting the requirements of home owners who desire an attractive jacketed type of round boiler.

The red enameled metal jacket is lined with multi-ply asbestocel insulation. Steam and water boilers are completely equipped with automatic regulation and all accessories.

Specifications

1—Steam gauge.

2—Large steam dome and disengaging surface.

3—Long, double flue.

4—Substantial doors. Fire, clinker, and cleanout doors equipped with special baffle linings.

5—Large fuel chamber.

6—Contacting-surfaces of doors ground to smooth finish.

7—Shaking mechanism, easily operated, durable.

8—Grates of reinforced, trussed construction.

9—Flow tapping.

10—Relief Valve.

11—Sensitive Arco Automatic Regulation.

12—Two-way smokehood with check and choke dampers.

13—One piece body casting. No assembling.

14—Steel jacket with baked enamel finish.

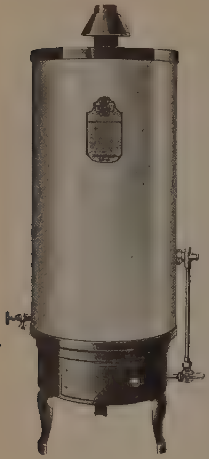
15—One-inch asbestocel insulation.

16—Rod with turn-buckle adjustment, connecting regulator and primary draft damper.

17—Base recess for precise jacket fitting.

18—Ashpit of ample size formed by strong cast iron base.

Tapped for Excelso Water Heater



IDEAL HOTCOIL

Gas Water Heater

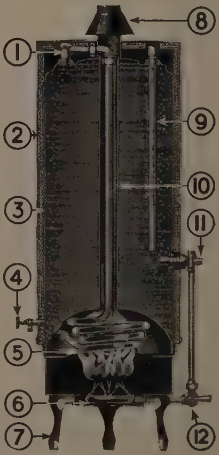
The New Hotcoil Water Heater functions with th highest degree of operating efficiency attainable fo practical service.

With green porcelain enamel top and base, in combination with the pearl-gray jacket, the beauty of this heate is virtually everlasting.

The Hotcoil Heater unites "flash" heating with th automatic storage factor, embodying the advantages o all other types of water heaters.

For communities in which the water contains chemicals which attack ordinary metals, a special model of the Hotcoil is available, made of non-corrosive Everdur Metal. This model is regularly equipped with automatic Pilot Control Valve—a valve that automatically stops the flow of gas if the pilot is extinguished or the gas pressure lowered.

Specifications



1—Special brass hot water flow-fitting.

2—Metal jacket with baked grey enamel finish, protecting one-inch asbestocel insulation.

3—Substantial heavy gauge tank, galvanized inside and outside.

4—Conveniently located brass drain cock.

5—Large bore, heavy gauge, one-piece copper coil heating element, insuring immediate hot water recovery.

6—Bunsen type gas burner with self pilot.

7—Substantial base and legs with porcelain enamel finish.

8—Porcelain enamel Back Draft Diverter Hood.

9—Non-syphon acting cold water intake.

10—Central water-surrounded flue containing copper coil heating element.

11—New Arco Automatic regulator with quick acting metallic bellows.

12—Main Gas Supply Control Valve and Dial.

Made in three sizes, 20, 30, 40 gallons.
Burns manufactured, mixed, or natural gas.

IDEAL KOLFLASH

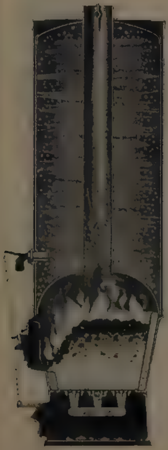
Coal-burning Water Heater

The firepot of the Kolflash Heater is made of cast iron with a one-inch non-heat-conducting refractory lining. Under ordinary operating conditions the temperature of the smooth, enameled and non-water-backed exterior of the firepot is no higher than the temperature of the water in the tank.

This lining not only contributes to the efficiency of the heater, but also provides for a quick pick-up capacity. For the lining retains the heat of the fire, and after a shaking-down and the addition of more fuel, the new charge of coal quickly ignites. The radiant heat of the glowing coals plays directly on the broad bottomed, water-backed surface of the tank, and the heated water rises, extracting increasing amounts of heat from the gases in the central flue.

The Ideal Kolflash Heater has been designed with deep firepot especially to provide for long firing periods.

Specifications



Large combustion chamber insures minimum attention.

For ordinary household demands this heater need be fired but twice a day.

One inch, non-heat-conducting refractory lining in firepot, prevents heat loss and insures quick pick-up heating capacity.

Water-surrounded flue insures maximum absorption of heat from the gases.

Extra-heavy shell insures durable service.

Arco Automatic Regulator keeps water at right temperature.

Flexible, sturdy grating especially designed for easy caretaking.

Outside jacket finished in beautiful French pearl gray. Base and top finished in beautiful green porcelain enamel.

AMERICAN RADIATOR COMPANY

General Sales and Eastern Executive Office
40 West 40th Street, **New York**

Western Executive Office and Accessories Division
816 South Michigan Avenue, CHICAGO, ILLINOIS

Manufacturers of Ideal Boilers, American Corto Radiators, and other Heating, Ventilating, and Refrigerating Products

---

PACKLESS VALVE

No. 999

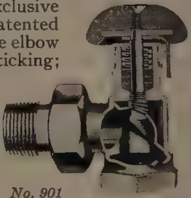
Arco Packless No. 999—leak-proof—does not require repacking. Does not stick or bind—opens with one smooth turn of special composition handle never gets hot. Furnished in either round or lever handle—made in angle, corner and globe patterns for steam, water, vapor or vacuum.

Arco Fractional Control Type No. 994

No. 994

Same as the No. 999 Packless with dial equipment and calibrating cone on disc.

Arco Packless Hot Water Equalizing Valve No. 901



No. 901

Combines three exclusive features: (1) Patented swinging plate, true elbow shape and non-sticking; (2) Arco Packless stem always turns easily and can never leak; (3) Equalizing feature permits adjustment of flow to individual radiator requirements after installation. Low in price.

No. 901 Round Handle. No. 904 Lever Handle.

PACKED VALVES

Detroit Steam Valves

No. 72

Metal well distributed—strong and heavy where strength is needed. Regularly equipped with composition handle, black hard rubber finish.

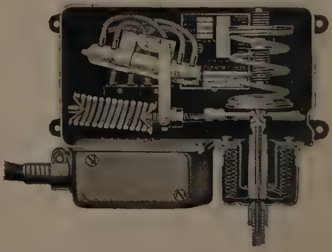
No. 72 Angle, No. 32 R. H. Corner, No. 37 L. H. Corner, No. 57 Globe, No. 373 Gate.

No. 845
Thermostat

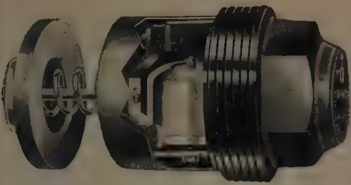
MERCOID CONTROLS

PATENTS PENDING

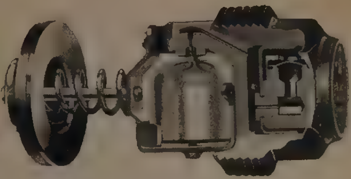
All Mercoid Controls employ the Mercoid Switch which carries the full line current at 110 or 220 volts without arcing or corrosion of contacts. Mercoid instruments give automatic control of temperature, pressure or vacuum. The various models provide a wide field of application. The No. 845 Mercoid Thermostat is especially adapted for use with Unit Heaters—starting or stopping the fan as the air temperature changes. The No. 847 Arco Motor Valve, for high or low pressure steam, water, air, etc., can be used with any Mercoid Control. Write for full details of this complete line.



No. 848 Type
For temperature, pressure, or vacuum



No. 1 In-Airid



No. 2 In-Airid with Cup Removed

IN-AIRID The Invisible Air Valve

The In-Airid No. 1 is a new type automatic Air Valve especially designed for radiators as now made for steam. Diverts steam to the bottom of the radiators completely eliminating all air. The In-Airid screws into the top plug opening in the vent end of the radiator and its baffle disc completely blocks off the opening to the last section. The operation of In-Airid is based on the same well known principle of the thermostatically charged float used so successfully in the famous Airid No. 500.

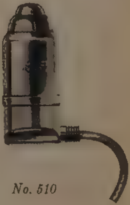
The In-Airid No. 2 is for "vacuum" jobs. It has all the venting features of the No. 1, plus the vacuum seal with hand-lapped monel disc and seat. It allows the air to escape but prevents its return into the system.

No. 500

AIRID AIR VALVES

The Airid No. 500 should be installed only on old style radiation which has nipple connections only at the bottom. For new type radiation with nipple connections at the top use the In-Airid.

Vac-Airid No. 510 is for "vacuum" jobs on old style radiation. It is designed to allow the air to escape but prevents its return into the system.



No. 510

ARCO REGULATORS

No. 800

Arco Water Regulator No. 800 is for damper control on hot water heating boilers, adjustable for temperature between 100 deg. and 220 deg.—all metal—length of bulb, 2½ in.; connection, 2 in. No. 801 Water Regulator for hot water supply heaters.

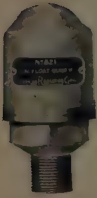
No. 905

ARCO STEAM REGULATOR NO. 905

For damper control on steam boilers—pressure up to 15 lbs. Connection 1 inch I.P.S. male thread—all metal—trimmings furnished.

IDEAL QUICK VENTS FOR ALL TYPES OF MAIN VENTING

No. 815, ¾ in. No. 820, ⅜ in. connection. Very sensitive. For mains, long runs of pipe, indirect stacks, drop risers, etc.



No. 821

Ideal Float Quick Vent No. 821 closes against water. ¾ in. male thread.

Ideal Vac-Vent No. 822 for Vacuum heating. Self-sealing against the return of air. ¾ in. male thread.

No. 351 Arco Packless Water Gauge is a necessary accessory on vacuum jobs because it is impossible to keep an ordinary gauge vacuum-tight. A permanent improvement for any below atmosphere heating plant. Fits any boiler.

No. 351

The Bigelow Company

ESTABLISHED 1860

Main Office and Works

New Haven, Connecticut

NEW YORK OFFICE—Graybar Building

Manufacturers of
Bigelow Hornsby Water Tube Boilers
Bigelow Horizontal Water Tube Boilers
Bigelow-Connelly Low Head Water Tube Boilers
Bigelow Horizontal Return Tubular Boilers
Bigelow Electric Steam Generators
Bigelow Two Pass Boilers
Bigelow Manning Boilers
Bigelow Upright Boilers

The Bigelow Two Pass Boiler for Heating and Power

The requirements in considering a boiler especially for steam heating—are first cost, efficiency and maintenance, and the steel heating boiler particularly the Bigelow Two Pass type we believe meets the above desired requirements most favorably.

First Cost—The F. O. B. price of a steel boiler is often higher than for other types, but, of course, the installed cost is the correct way to figure. For the proper erection of a sectional boiler experienced and high priced men are required while the Bigelow Two-Pass Boiler is shipped practically all assembled and requires but a small amount of mason work.

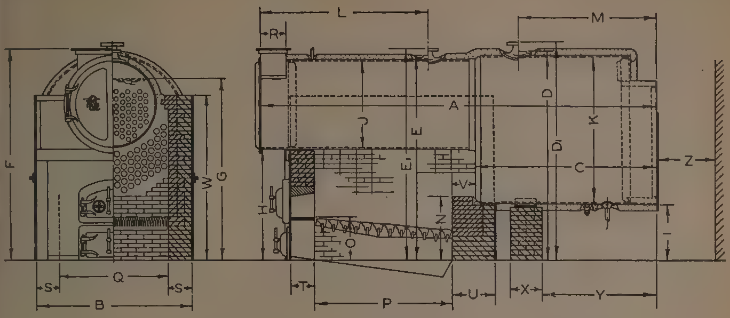
Efficiency—Correctly designed as a heat absorbing piece of apparatus, the area of the gas passage in the first pass is approximately one third greater than that of the return pass. This results in better heat transmission, due to the more uniform velocity of the gases over the heating surface as they are cooled.

The furnace is constructed of standard fire and red brick and is encased in a heavy sectional plate steel casing which adds to the neat appearance of the installation and prevents infiltration of air through cracks that may develop in the brick work.

Maintenance—The Bigelow Two-Pass Boiler is constructed without crown sheet or water legs, so there are no staybolts to break and cause leakage or danger of rupture. Being constructed of steel, there is no likelihood of cracking sections due to sudden changes of temperature, variation in thickness of material under pressure, and no unequal strains are set up in assembling. The many installations of the Bigelow Two-Pass Boiler both for heating and power, have proven it to be economical in operation and low in maintenance cost.

Features of the Bigelow Two-Pass Boiler

No Staybolts
Easy to Install
Quick Steamer
Low Draft Loss
Easy to Handle
Long Gas Travel
Efficient to Operate
Low Maintenance Cost
Ample Water Capacity
Occupies Small Floor Space
Low Exit Gas Temperature
Ample Steam Storage Capacity
Inside of Boiler Readily Accessible
Furnace Suitable for Oil Burning
No Cast Iron in Contact with Pressure
Large Furnace Volume for Combustion
Area of Gas Passes Properly Proportioned
No Special Brick Shapes Required for Furnace
Constructed to A.S.M.E., or Mass. State Requirements
Fire Brick Furnace Walls, which Aids Combustion
Built in Units of 25, 50, 75, 100, 125 and 150 hp.
All Sizes Built as a Standard for 15 and 125 lb. W. P.
Brick Work Easily and Cheaply Repaired when Necessary
Boiler Rating Based on 10 sq. ft. of Water Heating Surface per hp.



GENERAL INFORMATION OF BIGELOW TWO-PASS BOILER

No. of Boiler for							
Heating, 15 lb. W. P......	....	240H	241H	242H	243H	244H	245H
Power, 125 lb. W. P......	....	240	241	242	243	244	245
Total Heating Surface................sq. ft.		270	505	751	1003	1273	1501
Capacity Steam Radiation............sq. ft.		3200	6000	9000	12000	15200	18000
Capacity Water Radiation............sq. ft.		5300	10000	14800	19800	25200	29700
Grate Area..........................sq. ft.		12.3	16.5	20.8	28.0	31.0	33.5
Diameter stack, one boiler..............in.		16	20	24	27	30	30
Diameter stack, two boilers.............in.		20	27	30	34	38	42
Height stack...........................feet		60	60	60	60	60	60
Area breeching, one boiler...........sq. ft.		1.3	2.2	3.0	3.8	4.5	5.2
Area breeching, two boilers..........sq. ft.		2.2	3.8	5.2	6.3	8.0	9.4
Size of steam outlet, 15 lb. W. P.........in.		6	6	8	8	8	8
Size of steam nozzle, 125 lb. W. P........in.		3	4	5	5	6	6
Size of safety valve outlet, 15 lb. W. P...in.		2	2½	3	4	4	4
Size of safety valve nozzle, 125 lb. W. P..in.		3	4	4	4	5	5
No. and size pop valves, 15 lb. W. P....in.		1-2″	1-2½″	1-3″	1-4″	1-4″	1-4″
No. and size pop valves, 125 lb. W. P....in.		1-2″	2-2″	2-2″	2-2½″	2-2½″	2-3″
Blow down and return conn., 15 lb. W. P...in.		3	3	3	4	4	4
Blow-off connection, 125 lb. W. P..........in.		2	2	2	2	2	2½
No. red brick required......................		1400	1550	1650	2100	2300	3000
No. fire brick required.....................		550	625	700	800	900	1100
Area of shell to be insulated..........sq. ft.		100	120	145	170	195	220
Weight bare boiler......................lbs.		4675	8482	10732	14000	16717	18823
Weight boiler comp. cstgs., trmgs. and steel casing..........................lbs.		7993	12492	15607	19841	23133	25859
Length over all......................ft. in.	A	11′ 9″	13′ 0″	14′ 1″	16′ 2″	16′ 4″	18′ 10″
Width overall........................ft. in.	B	5′ 4″	5′ 11″	6′ 5″	6′ 11″	7′ 5″	7′ 5″
Length large shell...................ft. in.	C	5′ 8″	6′ 2″	6′ 8″	7′ 8″	7′ 8″	8′ 8″
Steam outlet to floor, 15 lb. W. P.....ft. in.	D	7′ 7⅜″	8′ 1½″	8′ 11″	9′ 3″	9′ 11⅛″	9′ 11⅛″
Steam nozzle to floor, 125 lb. W. P....ft. in.	D1	7′ 9 7/16″	8′ 4 9/16″	9′ 1⅝″	9′ 5¾″	10′ 1 13/16″	10′ 1 13/16″
Safety valve outlet to floor, 15 lb. W.P., ft. in.	E	7′ 4″	7′ 10¼″	8′ 7¼″	8′ 11⅝″	9′ 7⅝″	9′ 7⅝″
Safety valve noz. to floor, 125 lb. W.P., ft. in.	E1	7′ 6¾″	8′ 1⅞″	8′ 10⅞″	9′ 2⅞″	9′ 11″	9′ 11″
Flue neck to floor...................ft. in.	F	7′ 9½″	8′ 3½″	9′ 0½″	9′ 4½″	10′ 0½″	10′ 0½″
Water line to floor..................ft. in.	G	6′ 5¼″	6′ 11 5/16″	7′ 8 5/16″	7′ 11¼″	8′ 6⅜″	8′ 6⅜″
Floor to shell at front of boiler.......ft. in.	H	4′ 7″	4′ 7″	5′ 0″	5′ 0″	5′ 4″	5′ 4″
Floor to shell at rear of boiler........ft. in.	I	2′ 10″	2′ 4″	2′ 7″	2′ 5″	2′ 7″	2′ 7″
Diameter of small shell..................in.	J	32″	38″	42″	46″	50″	50″
Diameter of large shell..................in.	K	54″	66″	72″	78″	84″	84″
Front of boiler to C safety valve nozzle, ft. in.	L	3′ 4″	4′ 7″	5′ 3″	6′ 3″	6′ 5″	8′ 0″
Rear of boiler to C steam nozzle,.......ft. in.	M	4′ 2″	4′ 2″	4′ 7″	5′ 8″	5′ 8″	6′ 7″
Height of bridge wall................ft. in.	N	3′ 3″	3′ 0″	3′ 1″	2′ 11″	2′ 11″	2′ 11″
Grate to floor.......................ft. in.	O	2′ 1″	2′ 1″	2′ 1″	2′ 1″	2′ 1″	2′ 1″
Length of furnace....................ft. in.	P	4′ 0″	4′ 6″	5′ 0″	6′ 0″	6′ 0″	6′ 6″
Width of furnace.....................ft. in.	Q	3′ 1″	3′ 8″	4′ 2″	4′ 8″	5′ 2″	5′ 2″
Size of flue neck ....in.	R	8″x22″	11″x24″	12½″x32″	13½″x36″	15½″x40″	15½″x42″
Thickness of side wall....................in.	S	13½″	13½″	13½″	13½″	13½″	13½″
Thickness of front wall...................in.	T	9″	9″	9″	9″	9″	13½″
Thickness of bridge wall at bottom...ft. in.	U	1′ 4″	1′ 4″	1′ 4″	1′ 4″	1′ 4″	2′ 0″
Thickness of bridge wall at top........ in.	V	6½″	6½″	6½″	6½″	6½″	14″
Floor to top of setting...............ft. in.	W	6′ 5″	6′ 8″	7′ 3″	7′ 5″	7′ 11″	7′ 11″
Depth and width of rear pier..........ft. in.	X	1′ 0″x3′ 0″	1′ 0″x3′ 0″	1′ 0″x3′ 6″	1′ 4″x4′ 0″	1′ 6″x4′ 6″	1′ 6″x4′ 6″
Back of pier to rear of boiler.........ft. in.	Y	3′ 1½″	3′ 7½″	4′ 1½″	4′ 9½″	4′ 7½″	5′ 7″
Distance required to open rear cleanout doors..........................ft. in.	Z	1′ 10″	2′ 1″	2′ 4″	2′ 6″	2′ 10″	2′ 10″

The Brownell Company

ESTABLISHED 1855

Dayton, Ohio

Representatives in Principal Cities

B

Manufacturers of

Welded and Riveted Steel Heating and Power Boilers—Screw Feed Automatic and Heavy Duty Ram Type Stokers—Also Tanks and Open and Closed Feed Water Heaters.

MASTER ELECTRIC WELDED STEEL BOILER

A superior quick steaming boiler occupying less space per unit of heating capacity

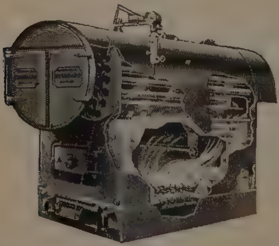
For Coal Hand Firing

For Stoker, Oil or Gas

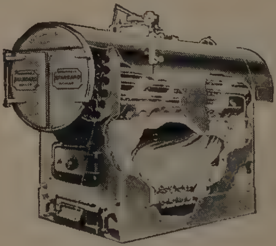
EXCLUSIVE FEATURES OF THE BROWNELL MASTER BOILER

A noteworthy feature, particularly where available space and height is a consideration, is the relatively small amount of space occupied by this boiler per unit of rating. In the same amount of space, the MASTER boiler will deliver from 12 to 23 per cent over normal rating. This is possible by the use of water tubes in the furnace extending the entire length of the boiler. This construction also lends itself to a more efficient gas or oil installation in conjunction with the use of incinerator grates, forming a four pass boiler with the extra pass directed **over** the incinerator grates causing a rapid and odorless consuming of the refuse.

STANDARD ELECTRIC WELDED STEEL BOILER



Smokeless Type



Direct Draft Type

The STANDARD boiler follows the same general lines as the MASTER, with the exception of the water tubes which have been omitted. The constructional advantages however, are the same for both. In designing these boilers, the principle thought was to insure free and unimpended circulation of the water and to increasing the structural strength beyond that generally found in boilers of this type. In our bulletins M-65 and S-65, which you probably have on file, full details of this construction are given.

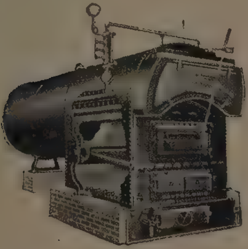
Brownell MASTER and STANDARD Electric Welded Steel Boilers

Built for 15 lb., w.s.p.—A. S. M. E. Code

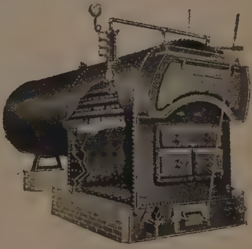
MASTER BOILER RATINGS				STANDARD BOILER RATINGS				Domestic Water per Hr. Gals.	Grate Area Sq. Ft.	Height Water Line In.	OVERALL DIMENSIONS		
Boiler No.	Capacity Steam Sq. Ft.	Capacity Water Sq. Ft.	Heating Surface Sq. Ft.	Boiler No.	Capacity Steam Sq. Ft.	Capacity Water Sq. Ft.	Heating Surface Sq. Ft.				Height In.	Width In.	Length In.
M-500-R	750	1200	56	....	....	....	....	40	3.6	50½	56	24	49¾
M-501-R	850	1360	65	....	....	....	....	40	4.2	50½	56	24	54¾
M-501	1100	1760	83	S-1	900	1440	76	40	5.3	50½	56	24	62¾
M-502	1350	2160	99	S-2	1100	1760	90	40	6.4	50½	56	24	71¾
M-503	1550	2480	118	S-3	1350	2160	107	40	7.5	55	61½	27	72¾
M-504	1850	2960	140	S-4	1650	2640	124	40	8.9	55	61½	27	81¾
M-505	2200	3520	162	S-5	1900	3040	146	75	10.0	58	66	30	84¾
M-506	2600	4160	191	S-6	2200	3520	172	75	11.0	58	66	30	96¾
M-507	3000	4800	228	S-7	2700	4320	207	75	11.1	62¼	74	36	93½
M-508	3550	5590	256	S-8	3000	4800	232	75	12.3	62¼	74	36	102½
M-509	4100	6560	288	S-9	3500	5600	261	75	13.6	62¼	74	36	112½
M-510	4900	7840	352	S-10	4250	6800	322	125	14.9	69¼	81	42	103½
M-511	5500	8800	395	S-11	4800	7680	361	125	16.4	69¼	81	42	113½
M-512	6100	9760	429	S-12	5300	8480	397	125	17.4	72½	87	48	103½
M-513	6600	10550	463	S-13	5700	9120	428	125	17.4	72½	87	48	109½
M-514	7200	11520	507	S-14	6500	10400	469	125	19.1	72½	87	48	117½
M-515	8200	13120	571	S-15	7200	11500	539	125	19.9	79½	93	54	109½
M-516	9100	14560	637	S-16	7900	12600	592	125	21.9	79½	93	54	117½
M-517	10000	16000	695	S-17	8700	13920	646	125	21.9	79½	93	54	125½
M-518	11500	18400	800	S-18	10000	16000	746	175	22.4	83¼	100	60	120½
M-519	13000	20800	906	S-19	11300	17970	845	175	22.4	83¼	100	60	132½
M-520	14300	22900	991	S-20	12500	20000	929	175	24.8	93½	111	66	122½
M-521	15250	24400	1058	S-21	13500	21600	992	175	24.8	93½	111	66	128½
M-522	16200	25900	1125	S-22	14500	23200	1054	175	27.3	93½	111	66	134½
M-523	18000	28800	1243	S-23	16000	25600	1173	225	30.0	97¼	118	72	128½
M-524	19000	30800	1320	S-24	17000	27200	1245	225	32.7	97¼	118	72	134½
M-525	21000	32800	1418	S-25	18000	28800	1337	225	35.5	97¼	118	72	142½
M-526	22500	36000	1539	S-26	20000	32000	1460	225	35.8	105	126	78	140½
M-527	24500	39200	1700	S-27	22000	35200	1612	225	38.8	105	126	78	152½

For ratings on stoker, oil or gas firing add 15 per cent to above ratings, or see our bulletins M-65 and S-65. First eight sizes contain no bridgewall—grates completely fill base.

PORTABLE FIREBOX HEATING BOILERS



Smokeless Type



Direct Draft Type

Regularly constructed according to A. S. M. E. Code for 15 lb., and 100 lb., w.s.p.

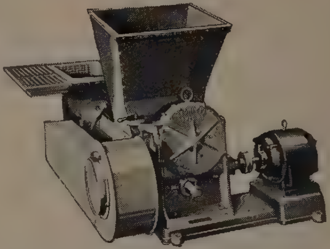
SMOKELESS TYPE				DIRECT DRAFT TYPE				Grate Area Sq. Ft.	Height Water Line In.	OVERALL DIMENSIONS		
Boiler No.	Capacity Steam Sq. Ft.	Capacity Water Sq. Ft.	Heating Surface Sq. Ft.	Boiler No.	Capacity Steam Sq. Ft.	Capacity Water Sq. Ft.	Heating Surface Sq. Ft.			Height In.	Width In.	Length In.
307	3000	5000	313	407	2500	4100	278	12.9	71	84	48	101
308	3500	5800	361	408	2900	4800	326	14.6	71	84	48	114
309	4000	6600	407	409	3500	5800	373	16.4	71	84	48	130
310	4500	7400	462	410	4000	6600	416	18.7	77½	90⅝	54	120
311	5000	8300	513	411	4500	7400	472	18.7	77½	90⅝	54	132
312	5500	9100	564	412	5000	8300	519	20.7	77½	90⅝	54	144
313	6000	9900	612	413	5500	9100	614	20.8	83	98	60	150
314	6500	10700	666	414	6000	9900	665	23.0	83	98	60	162

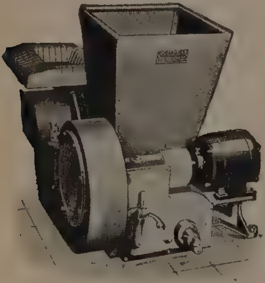
Continued at foot of next page

B

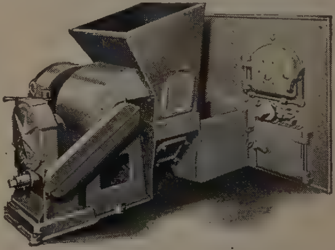
THE BROWNELL AUTOMATIC UNDERFEED STOKER
Type A-1

In the construction of mechanical stokers, the importance of correct design is paramount; much more so than in many other types of mechanical equipment. A stoker does not only have to operate efficiently under inexperienced and careless handling, but must also be able to resist an abnormal degree of wear and tear due to grit, dust and ashes generally prevelant in boiler rooms and the high temperatures it must resit.





This condition of correct design and fabrication can only be secured in a stoker where each part is designed to fit every other part and constructed in one factory where the superintendence and manufacturing methods are uniform. For seventy-five years, the **Brownell Company** has turned out combustion and mechanical apparatus which has been used in all parts of the world, and which has helped create the traditions which are strongly fused in all present **Brownell** products. **The Brownell Company** stands squarely behind each product.



The various types stokers illustrated on this page are daily serving thousands of satisfied users in all types of installations from residence to power plants, for both high and low pressure. Three distinctive models are here illustrated. All of these models incorporate the exclusive **Brownell** feature of **synchronized coal and air delivery.** Regardless of the speed or combustion rate, the correct amount of air is always supplied automatically. The importance of this feature will instantly be recognized by every engineer.

The **Side Dump Stoker,** illustrated above, is the highest type of combustion equipment possible to manufacture. It is rugged and well built, and reduced to the fewest elements necessary for successful and efficient operation at the lowest maintenance. The side dump feature is particularly desirable where high combustion rates are necessary as it permits of a rapid disposal of the ash without labor and the necessity of opening the fire doors.

Need we remind you that our engineering staff is always ready and willing to assist you in any problem; gladly and without obligation.

Portable Steel Boiler Specifications—*Continued from previous page*

SMOKELESS TYPE				DIRECT DRAFT TYPE				Grate Area Sq. Ft.	Height Water Line In.	OVER ALL DIMENSIONS		
Boiler No.	Capacity Steam Sq. Ft.	Capacity Water Sq. Ft.	Heating Surface Sq. Ft.	Boiler No.	Capacity Steam Sq. Ft.	Capacity Water Sq. Ft.	Heating Surface Sq. Ft.			Height In.	Width In.	Length In.
315	7500	12400	744	415	7000	11600	696	23.0	83	98	60	168
316	8500	14000	797	416	8000	13200	779	25.3	83	98	60	186
317	10000	16500	914	417	9500	15700	929	25.5	90	107	66	188
318	12000	19800	1053	418	11000	18200	1049	28.0	90	107	66	212
319	14000	23100	1206	419	13000	21500	1168	30.9	96	112½	72	190
320	16000	26400	1316	420	15000	24800	1303	33.6	96	112½	72	210
321	18000	29700	1475	421	17500	28500	1519	36.7	97	115	78	214
322	20000	33000	1566	422	20000	32000	1716	39.6	97	115	78	238
323	25000	40000	2098	423	25000	40000	2175	42.8	104	120	84	240
324	30000	48000	2637	424	28000	45000	2431	46.1	104	120	84	264

Burnham Boiler Corporation

Irvington-on-Hudson, New York

Makers of High and Low Pressure Cast Iron Heating Boilers

New York Office: GRAYBAR BUILDING

Offices: BOSTON; PHILADELPHIA; CHICAGO; QUEENS VILLAGE, L. I.; SAN FRANCISCO; BALTIMORE; SPRINGFIELD; LANCASTER

Plants at IRVINGTON, N. Y.; ELIZABETH, N. J.; LANCASTER, PA.; ZANESVILLE, OHIO

There's a Burnham for every Heating purpose

RATING FOR STEAM

No.	Rating Sq. Ft.	No. and Size of Outlet and Inlet	Average Size of Fire Pot	Grate Area Sq. Ft.
S-50-6	7850	3-5″	55 x 55.5	19.27
S-50-7	9300	3-5″	55 x 66	22.92
S-50-8	10,750	4-5″	55 x 76.5	26.56
S-50-9	12,200	4-5″	55 x 87	30.20
S-50-10	13,650	5-5″	55 x 97.5	33.85
S-50-11	15,100	5-5″	55 x 97.5	33.85
S-50-12	16,550	5-5″	55 x 97.5	33.85

RATING FOR WATER

W-50-6	12,600	4-5″	55 x 55.5	19.27
W-50-7	15,000	4-5″	55 x 66	22.92
W-50-8	17,400	5-5″	55 x 76.5	26.56
W-50-9	19,800	5-5″	55 x 87	30.20
W-50-10	22,200	6-5″	55 x 97.5	33.85
W-50-11	24,600	6-5″	55 x 97.5	33.85
W-50-12	27,000	6-5″	55 x 97.5	33.85

Burnham Big Twin Sectional Cast Iron Boiler

The Big Twin will handle large heating jobs in apartment houses, hotels, churches and other large buildings.

It has the Burnham three-way fire-travel that keeps fuel costs low, and it has all the endurance features that are found in good cast iron boilers.

Big Twin gets its name from its divided sections, divided along the ridge of the boiler from front to back. Because of this division there is no part of the entire boiler that cannot be carried through any opening a man can pass through sidewise. Intermediate sections are interchangeable.

Big Twin grates are divided also into four sections, shaken separately.

Short Tie Bolts connect the sections of the Big Twin. Three men can set it up in a surprisingly short time. Sections are 10 in. broad.

This half section is one of the twins. It can be turned right or left and fit in equally well, and can easily be handled by two men.

Catalogue gives full information concerning our complete line of Burnham Boilers for Heating and Hot Water Supply

Coatesville Boiler Works

Coatesville, Pa.

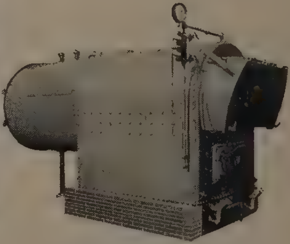
Main Office and Works: COATESVILLE, PA.

PHILADELPHIA, 111 South 15th Street
NEW YORK CITY, 30 Church Street
SAN FRANCISCO, St. Clair Bldg.
PITTSBURGH, Union Trust Bldg.
BALTIMORE, Lexington Bldg.
NEWARK, 60 Park Place

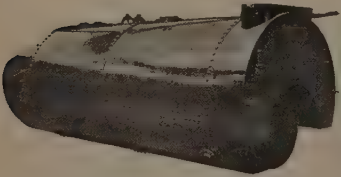
Heating and Power Boilers—Steel Tanks—Heavy Steel Plate Work

Coatesville "Series A" Welded Heating Boiler 15 lb. Working Pressure

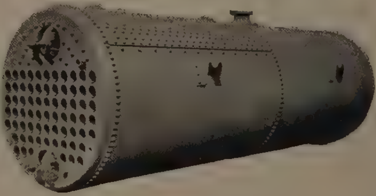
Coatesville Vertical Boiler 100 and 125 lb. Working Pressure



Coatesville Riveted Fire Box Boiler Heating and Power



Coatesville Scotch Marine Type Boiler Power and Heating



Coatesville Horizontal Return Tubular Boiler Power and Heating

Heating Boilers—Coatesville Standard low-pressure heating boilers of regular fire box type of return tubular design, having two passes through the tubes. There are four series, each of 23 sizes. Series A, for anthracite coal; Series B, updraft, for bituminous coal; Series D, downdraft, for bituminous coal; Series C, for oil or gas fuel. These boilers for low-pressure heating (15 lb.) are of fusion weld construction, for 100 lb. working pressure they are of riveted construction.

Power Boilers—Coatesville Power Boilers are made in all types and sizes of fire tube design. The types are the Horizontal Return Tubular, Firebox Return Tubular, Locomotive Firebox, Dry Back Scotch, Wet Back Scotch, Vertical and Special boilers such as for waste heat installation.

Tanks—Storage tanks are carried in stock for quick delivery. Tanks are built to meet all requirements, as to the shape, size, pressure, or material.

Miscellaneous Plate Work—This includes steel stacks either guyed or self supporting, breechings, towers, stills, bins, hoppers and other special plate work.

Bulletins on any standard product gladly sent.

Central Radiator Company

Subsidiary of The Universal Pipe and Radiator Company

LANSDALE-CRAIG WATER TUBE BOILERS

(Also "The Gray Sentry" Jacketed Boilers and Lansdale Round Boilers)

GRAYBAR BUILDING, LEXINGTON AVENUE AT 43rd STREET, NEW YORK

PHILADELPHIA BRANCH
2401 Chestnut Street

LANSDALE, PA. BRANCH
50 Central Avenue

CHICAGO BRANCH
332 S. Michigan Avenue

Tested and Certified by Outside and Unbiased Engineers.

Heating Surface Doubled . . . No Dead Corners . . . the forward and back fire travel—the corrugated front, back, sides and rounded corners and the large drop tubes over the fire, assume double the heating surface.

Tests have been made not alone by our own engineers, but in the nationally-known Frost Research Laboratory, at Norristown, Pa.—and these laboratory tests are certified by Mr. Robinson V. Frost, C. E., Member A. S. M. E. and A. S. H. & V. E.

Constructed in accordance with the codes of the A. S. M. E. and A. S. H. & V. E. Rated in accordance with the code of Heating and Piping Contractors National Association.

Ask nearest office for charts showing boiler performances, efficiencies, grate areas and ratings.

STEAM or VAPOR			STEAM, VAPOR and WATER										WATER	
Boiler No. STEAM	Commercial Rating *STEAM	Water Line Inches	Grate Area Square Feet	Height from Floor to Outlet Inches	Height from Floor to Center Return Inlet, Inches	Height Overall Inches	Width including Trimmings Inches	Length of Boiler including Smoke Box, Inches	Tapping Outlets and Inlets Inches	Smoke Pipe Diameter Inches	Boiler Foundation Inches	Shipping Weight Approximate Pounds	Boiler No. WATER	Commercial Rating *WATER
15–3 S	350	42	1.15	51	13½	57	34	32	1–2½	8	19x16	921	3–15W	550
15–4 S	500	42	1.67	51	13½	57	34	37	1–2½	8	19x21	1078	4–15W	800
15–5 S	700	42	2.19	51	13½	57	34	42	1–2½	8	19x26	1235	5–15W	1100
15–6 S	900	42	2.71	51	13½	57	34	47	2–2½	8	19x31	1388	6–15W	1400
15–7 S	1050	42	3.23	51	13½	57	34	52	2–2½	8	19x36	1540	7–15W	1650
22–4 S	800	47	3.05	57	14	61	42	43	1–3	10	26x25	1580	4–22W	1300
22–5 S	1100	47	3.97	57	14	61	42	49	2–3	10	26x31	1842	5–22W	1750
22–6 S	1400	47	4.89	57	14	61	42	55	2–3	10	26x37	2096	6–22W	2250
22–7 S	1750	47	5.80	57	14	61	42	61	2–3	10	26x43	2354	7–22W	2700
22–8 S	2025	47	6.72	57	14	61	42	67	2–3	12	26x49	2620	8–22W	3250
24–5 S	1300	52	4.33	70	18	70	56	57	2–3	10	33x33	2475	5–24W	2100
24–6 S	1650	52	5.33	70	18	70	56	63	2–3	10	33x39	2856	6–24W	2600
24–7 S	2000	52	6.33	70	18	70	56	70	2–3	10	33x45	3236	7–24W	3200
24–8 S	2300	52	7.33	70	18	70	56	76	2–3½	12	33x51	3638	8–24W	3650
24–9 S	2500	52	8.33	70	18	70	56	82	2–4	12	33x57	4018	9–24W	4050
24–10 S	2800	52	9.33	70	18	70	56	88	2–4	12	33x63	4398	10–24W	4500
36–7 S	3600	59	9.50	71	18	71	70	73	2–4	14	45x45	4879	7–36W	5750
36–8 S	4200	59	11.00	71	18	71	70	79	2–4	14	45x51	5458	8–36W	6750
36–9 S	4700	59	12.50	71	18	71	70	86	3–4	14	45x57	6006	9–36W	7500
36–10 S	5200	59	14.00	71	18	71	70	92	3–4	16	45x63	6576	10–36W	8300
36–11 S	5700	59	15.50	71	18	71	70	98	3–4	16	45x70	7151	11–36W	9000
36–12 S	6200	59	17.00	71	18	71	70	104	3–4	16	45x76	7721	12–36W	9900
36–13 S	6500	59	18.50	71	18	71	70	111	4–4	20	45x82	8293	13–36W	10450
36–14 S	6950	59	20.00	71	18	71	70	117	4–4	20	45x89	8875	14–36W	11100

*When domestic hot water supply tank is to be heated by heating boiler add to actual load 2 sq. ft. for each gallon of tank capacity on a steam job, and 3 sq. ft. for each gallon on a hot water job.

HEADERS: All 24 in. series Supply Headers are 5 in. All 24 in series Return (Two), Headers are 4 in. All 36 in. series Supply Headers are 7½ in. All 36 in. series Return (Two), Headers are 4 in. All headers are tapped 2 in. on Rear End.

COAL-BURNING BOILERS: Steam Boilers furnished complete with steam gauge, safety-valve, gauge glass, gauge glass fittings, tri-cocks, firing tools, regulator. Water Boilers furnished with firing tools.

OIL-BURNING BOILERS: All oil-burning boilers come without grates and without firing tools.

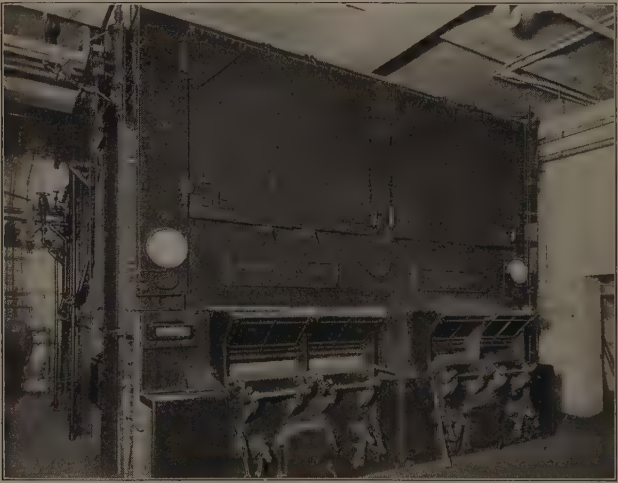
Edge Moor Iron Company

Edge Moor, Delaware

New York.....420 Lexington Ave.
Los Angeles.....114 West 17th St.
Chicago.....1549 Otis Bldg.
Charlotte, N. C.....1408 Independence Bldg.
St. Paul.....Fourth and Wacouta Sts.

Designers and Builders of

EDGE MOOR WATER TUBE BOILERS



Battery of Edge Moor *Heating Boilers at Homeopathic Hospital, Wilmington, Del.*

THE EDGE MOOR HEATING BOILER

An all-steel water tube boiler of high efficiency for buildings requiring 21,000 sq. ft. and more of steam radiation. Made in four sizes, from 150 hp. to 300 hp.

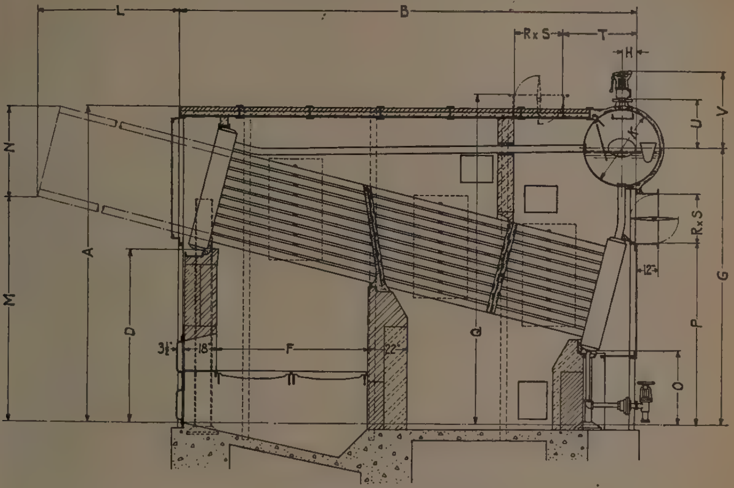
Because it is adapted to power loads up to 160 lbs. per sq. in. working pressure, this boiler is especially suitable for office buildings, hotels, large apartments, schools, hospitals, municipal buildings, theatres, garages, warehouses and similar installations where steam is required for power and other purposes in addition to heating.

The Edge Moor Heating Boiler follows the same general design and construction used in the Edge Moor Cross Drum Boiler for high-pressure service, which is serving many industries. It is built to the same high standards of quality, fully complying with all *A. S. M. E.* Code and local requirements.

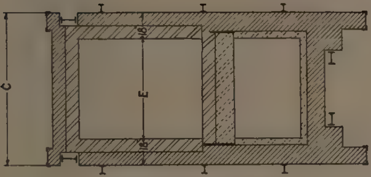
Adaptable to various fuels and firing methods, including stoker-firing.

Table on following page gives dimensions, capacities and other data.
For further information, address our nearest office.

THE EDGE MOOR HEATING BOILER

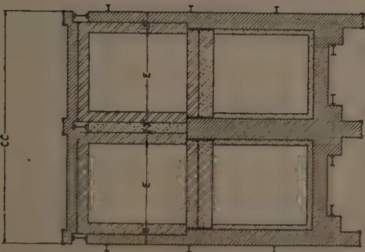


SECTIONAL SIDE ELEVATION



SECTIONAL PLAN-SINGLE SETTING

Boiler Number		150	200	250	300
Heating Surface	sq-ft	1500	2000	2500	3000
Capacity, Steam (at Normal Boiler Rating)	sq ft	21000	28000	35000	42000
A—Floor to Top of Boiler	ft.-in	14-8	14-8	14-8	14-8
B—Length of Boiler Setting	ft-in	18-2	18-2	18-2	21-2
C—Width of Boiler Single Setting	ft-in	8-8	10-7½	12-6½	12-6½
CC—Width of Boiler Battery Setting	ft-in	16-7	20-6	24-4	24-4
D—Floor to Bottom of Front Header	ft-in	8-0	8-0	8-0	8-0
E—Width of Furnace	ft-in	5-8	7-7½	9-6½	9-6½
F—Depth of Furnace	ft-in	7-0	7-0	7-0	7-0
G—Floor to ℄ of Drum	ft-in	12-10⅜	12-10⅜	12-10⅜	12-10⅜
H—℄ of Drum to Rear Face Brickwork	in	7	7	7	8⅛
K—Diameter of Drum	in	42	42	42	42
L—Space Required to Remove Tubes	ft-in	14-0	14-0	14-0	17-0
M— " " " " "	ft-in.	12-4½	12-4½	12-4½	13-0
N— " " " " "	ft-in	4-2	4-2	4-2	4-2
O—Floor to Bottom of Rear Header	ft-in.	4-2⅛	4-2⅛	4-2⅛	3-5⅜
P—Floor to Breeching Conn. Gas out Rear	ft-in.	9-2⅜	9-2⅜	9-2⅜	8-5½
Q— " " " " " " Top	ft-in.	15-2	15-2	15-2	15-2
R—Breeching Conn. Width	ft-in.	1-6	1-6	1-6	2-3
S— " " Length	ft-in.	6-7½	8-7	10-6	10-6
T—Rear of Boiler to Breeching Conn.	ft-in.	2-8	2-8	2-8	3-4½
U—℄ Drum to Top of Steam Outlet	ft-in.	2-3½	2-3½	2-3½	2-4½
V—℄ Drum to Top of Pop Valve	ft-in	3-3	3-3	3-3	3-6
Number of Firebrick-Single Setting		5400	6100	6700	7700
" " Redbrick- " "		13200	13700	14200	15900
" " Firebrick-Battery "		11300	12600	13400	15900
" " Redbrick- " "		22600	23700	24700	27500
Shipping Weight of One Boiler	lbs	39250	47300	56650	62700
Total Weight filled with Water	lbs	43000	57000	71500	77500



SECTIONAL PLAN-BATTERY

EDGE MOOR
Water Tube BOILERS

Fitzgibbons Boiler Co., Inc.

570 Seventh Avenue, **New York City**
Works: Oswego, N. Y.
Offices in Principal Cities

PRODUCTS

Fitzgibbons Copper Steel Boilers for Steam or Hot Water Heating. Table 1.

Fitzgibbons Copper Steel Smokeless Boilers for Steam or Hot Water Heating. Table 1-B.

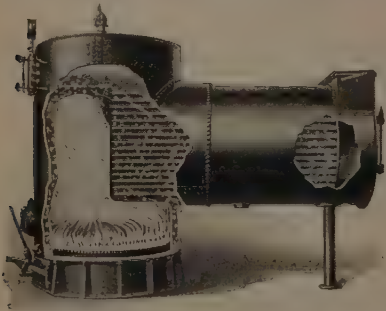
Fitzgibbons (Intermediate Sized) Steel Boilers for Steam or Hot Water Heating. Table 2.

Fitzgibbons All Riveted Steel Boilers for Heating and for Power. 15 lbs. to 150 lbs. w.s.p.—*A.S.M.E.* Code.

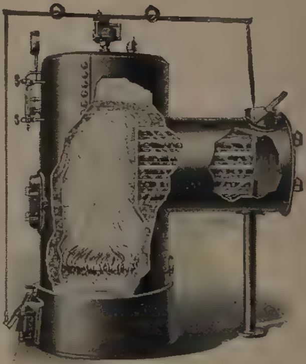
Fitzgibbons Steel Boilers: Embodying the original Fitzgibbons cylindrical furnace, entirely free from brickwork, the high combustion chamber, the gas-deflecting arch, the secondary air preheater, and the effective single pass of many relatively small tubes, Fitzgibbons Steel Boilers have, for more than forty years, proved their twin qualities, notable fuel economy and lifetime service, substantially without maintenance expense.

Construction: The cylindrical design of the Fitzgibbons Steel Boiler affords the strongest possible construction with minimum of internal bracing; and the complete water-jacketing of the vertical furnace insures exceptionally long life as well as high efficiency. The entire interior of the Boiler is visible and accessible for inspection or cleaning.

Combustion: Complete combustion of the fuel and its consumable gases is attained with a minimum of excess air. The circular Fitzgibbons grate is free from dead corners and maintains a hot, uniform fire. The wholly visible grate encourages and assists careful firing. The high cylindrical combustion chamber is now recognized as essential to complete combustion. The rear gas-deflecting arch diverts the gases forward into intimate mixture with the preheated secondary air which enters through a port above the firing door. As the air-gas mixture whirls upward combustion is completed before the gases enter the tubes, resulting in very high furnace temperatures,—often close to 3000 deg. fahr. Smokeless combustion of semi-bituminous coal indicates the thoroness of this combustion.



Fitzgibbons Steel Heating Boiler. Table 2



Fitzgibbons Copper-Steel Heating Boiler for small-sized installations, homes, churches, garages, etc.

Conduction and Circulation: The absorption of the heat so effectively generated in the Fitzgibbons furnace is accomplished by the unique design of this time-proved Boiler. The water line is carried in the vertical shell directly above the combustion chamber, the horizontal tube Cylinder being completely filled with water. Therefore the circulation of the water is extremely rapid as the boiler steams and the bubbles move along fixed paths toward the steam chamber. This rapid circulation insures heat absorption as effective as the heat generation accomplished in the furnace as is evidenced by (1) the quick-steaming capacity, (2) less than 1 per cent moisture in steam regardless of overload carried, and (3) unusually low flue-gas temperatures.

Detailed Information will be mailed promptly upon request.

ABLES 1 AND 1-B COMBINED—FITZGIBBONS STEEL HEATING & SMOKELESS HEATING BOILERS
Double-Electric-Welded Furnaces
Sizes 300 to 3200 sq. ft. Steam Rating—Built for 15 lb. w.s.p.—A.S.M.E. Code

No. of Boiler..........	J-6	J-8	H-8	J-10	J-12	H-16	H-20	H-24	H-28	H-32	H-36	H-44	H-50	H-58	H-64
No. of Smokeless Boiler..	None	None	B-8	B-10	B-12	B-16	B-20	B-24	B-28	B-32	B-36	B-44	B-50	B-58	B-64
Steam Rating.......sq. ft.	300	400	400	500	600	800	1000	1200	1400	1600	1800	2200	2500	2900	3200
Hot Water Rating...sq. ft.	500	700	700	800	1000	1300	1600	1900	2200	2600	2900	3500	4000	4600	5100
Heating Surface.....sq. ft.	30	33	35	43	51	67	78	95	108	123	150	192	233	249	295
Comp. Grate Area. .sq. ft.	2.5	2.5	3.36	3.36	3.36	4.35	4.35	5.84	5.84	7.10	7.10	8.50	8.50	10.00	10.00
Diam. Vertical Shell ...in.	23	23	26	26	26	29	29	33	33	37	37	40	40	43	43
Length Bare Boiler..ft. in.	3-3	3-3	3-9	4-1	4-5	4-9	5-3	5-8	6-2	6-9	7-9	7-7	8-7	8-4	9-4
Diam. Horizontal Shell..in.	18	18	18	18	18	21	21	23	23	27	27	31	31	33	33
Water Line.........ft. in.	3-5	3-5	3-7	3-7	3-7	4-0	4-0	4-4	4-4	4-7	4-7	4-11	4-11	5-2	5-2
Diameter Base.........in.	26½	26½	30	30	30	33½	33½	37½	37½	40½	40½	42¾	42¾	45¾	45¾
Fire Door Center.......in.	25½	25½	27	27	27	31	31	31	31	31	31	31	31	31	31
Overall Height......ft. in.	4-2	4-2	4-3	4-3	4-3	4-8	4-8	5-0	5-0	5-5	5-5	5-9	5-9	6-1	6-1
Width of Uptake.......in.	5½	5½	5½	5½	5½	6½	6½	7½	7½	8½	8½	9½	9½	10	10
Length of Uptake......in.	12½	12½	12½	12½	12½	15½	15½	17½	17½	20½	20½	22	22	25	25
Tube Space...........in.	18	18	18	18	22	24	30	27	32	31	43	35	47	40	52
Grate Diameter........in.	19	19	22	22	22	25	25	29	29	32	32	35	35	38	38
Stack Diameter........in.	8	8	8	8	8	10	10	12	12	14	14	16	16	18	18
Stack Height..........ft.	35	40	40	45	45	40	45	45	45	50	50	50	60	60	60
Shipping Weight......lbs.	900	920	1150	1175	1225	1525	1625	2000	2100	2400	2460	3000	3200	3550	3800

TABLE 2—FITZGIBBONS STEEL HEATING BOILERS
Double-Electric-Welded Furnaces
Sizes 3800 to 19000 sq. ft. Steam Rating—Built for 15 lb. w.s.p.—A.S.M.E. Code

No. of Boiler...........	H-76	H-86	H-98	H-108	H-120	H-132	H-144	H-160	H-170	H-200	H-220	H-250	H-270	H-310	H-330	H-360	H-380
Steam Rating.......sq. ft.	3800	4300	4900	5400	6000	6600	7200	8000	8500	10000	11000	12500	13500	15500	16500	18000	19000
Hot Water Rating...sq. ft.	6000	6900	7900	8700	9600	11000	12000	13500	14500	16000	17500	20000	21500	25000	26500	29000	30500
Heating Surface.....sq. ft.	354	393	397	428	497	582	665	674	772	826	920	1048	1109	1308	1372	1511	1571
Comp. Grate Area...sq. ft.	12.8	12.8	15.4	15.4	18.8	18.8	18.8	21.0	21.0	24.2	24.2	29.4	29.4	32.0	32.0	36.0	36.0
Diam. Vert. Shell....ft. in.	4-0	4-0	4-4	4-4	4-9	4-9	4-9	5-0	5-0	5-4	5-4	5-10	5-10	6-2	6-2	6-6	6 6
Length Bare Boiler...ft. in.	9-1	10-1	9-7	10-7	9-9	10-9	11-9	10-10	11-10	11-10	12-10	12-2	12-8	14-0	14-6	14-3	15-2
Diam. Horiz. Shell...ft. in.	3-4	3-4	3-6	3-6	4-0	4-0	4-0	4-3	4-3	4-6	4-6	5-0	5-0	5-2	5-2	5-6	5-6
Water Line.........ft. in.	6-0	6-0	6-0	6-0	6-7	6-7	6-7	6-11	6-11	8-3	8-3	8-9	8-9	8-11	8-11	9-6	9-6
Overall Height.... .ft. in.	7-1	7-1	7-2	7-2	7-10	7-10	7-10	8-2	8-2	9-5	9-5	10-0	10-0	10-2	10-2	11-0	11-0
Smoke Uptake.....in. x in.	13½x26	13½x26	14x27	14x27	14x37	14x37	14x37	14x44	14x44	15x49	15x49	16x58	16x58	17x58	17x58	18x63	18x63
Tube Space ....ft. in.	3-10	4-10	3-9	4-9	3-9	4-9	5-9	4-9	5-9	6-7	7-7	6-6	7-0	7-10	8-4	7-9	8-8
Grate Diameter........in.	43	43	47	47	52	52	52	55	55	59	59	65	65	68	68	72	72
Stack Diameter........in.	20	22	22	22	24	24	24	26	26	28	30	30	30	32	32	34	34
Stack Height ....ft.	60	65	65	70	70	70	70	80	80	80	80	85	85	100	100	125	125
Shipping Weight ......lbs.	5250	6100	6650	7400	9000	9500	10000	10500	11000	13000	13800	15200	16000	18400	19000	19500	20500

TABLE 3—FITZGIBBONS STEEL HEATING AND POWER BOILERS
All-Riveted Construction—A.S.M.E. Code
Sizes 4200 to 36000 sq. ft. Steam Rating—Heating Boilers Built for 15 lb. w.s.p.
Power Boilers, for Kitchen, Laundry, Drying, Process and Similar
High-Pressure Loads, Built for 100 lb. w.s.p.

No. of Boiler..................	23	24	25	26	27	29	30	31	32	33	34	35	36	37
Horse Power.................	**40**	**50**	**60**	**70**	**80**	**100**	**125**	**150**	**175**	**200**	**225**	**250**	**300**	**350**
Steam Rating ....sq. ft.	4200	5400	6400	7500	8500	11000	13500	16500	19000	22000	25000	28000	32000	36000
Hot Water Rating...... .....sq. ft.	6700	8700	10500	12000	14500	17500	21500	26500	30500	35000	40000	45000	51000	58000
Heating Surface ....sq. ft.	380	456	547	631	721	917	1147	1350	1571	1823	2012	2271	2760	3220
Comparative Grate Area .. .sq. ft.	13.2	15.3	17.4	18.8	21.0	24.2	29.4	33.0	36.0	38.1	40.2	44.5	50.2	57.5
Diameter Vertical Shell........ft. in.	4-1	4-5	4-8	4-10	5-1	5-5	5-11	6-3	6-7	6-9	6-11	7 3	7-8	8-4
Height Overall .... ft. in.	8-6	8-9	9-2	9-5	9-9	10-1	10-8	11-0	11-11	12-1	12-2	12-6	13-0	13-6
Length Bare Boiler ....ft. in.	9-4	10-6	10-9	12-2	12-3	13-7	13-11	15-1	15-4	16-2	17-5	18-2	19-2	19-6
Diameter Horizontal Shell . . .ft. in.	3-5	3-8	3-11	4-1	4-4	4-7	5-1	5-3	5-7	5-9	5-9	6-1	6-6	7-1
Smoke Uptake ....in. x in.	12x24	12x31	13x36	13x42	13x48	14½x49	15½x58	17x58	18x62½	19x65	19x65	20x68	24x73	24x80
Space to Draw Tubes.........ft. in.	4-8	5-7	5-6	6-10	6-10	7-9	7-8	8-6	8-4	8-10	10-0	10-5	11-0	11-0
Water Line ....ft. in.	7-1	7-4	7-8	7-11	8-2	8-5	8-11	9-1	9-10	10-1	10-1	10-5	11-4	11-10
Grate Diameter..................in.	43	47	50	52	55	59	65	68	72	74	76	80	85	91
Stack Diameter..................in.	22	22	24	24	26	28	30	32	34	34	38	40	48	48
Stack Height ....ft.	65	70	70	70	80	80	90	100	125	140	140	140	165	190
Shipping Weight...............lbs.	7500	9500	10000	11500	12000	15200	18000	20000	23000	26000	29000	32000	37000	44000

*It has been established that the Circular Grate *in the Fitzgibbons Cylindrical Furnace* is more effective than a ectangular grate the size of the circumscribed square. Hence, for comparative purposes, the **Comparative Grate Area** shown in the Tables is the area of the square circumscribed upon a circle the size of the Fitzgibbons Grate.

Erie City Iron Works

STEARNS DIVISION

Erie, Pa.

WELDED STEEL HEATING BOILERS

Sales Offices in Principal Cities

Coal Fired Type

Oil or Gas Fired

The Erie City Welded Steel Heating Boiler is built in 18 sizes, 3,500 to 28,000 sq. ft. of steam radiation capacity, for coal, oil or gas firing.

A few of the many features of design incorporated in this sturdy boiler that every heating engineer will appreciate are as follows:

Specially designed water-cooled refractory arch insures smokeless operation.

Long travel of products of combustion through 3 in. fire tubes insures low exit temperature and high efficiencies.

Large fire box and grate area permit extended firing periods and less frequent ash removal.

Front and rear smoke chambers are built into the boiler so that there are no protruding parts.

Gas passes are correctly proportioned to insure correct velocities through the different passes of the boiler.

Draft loss is exceptionally low, making it possible to carry heavy fires without seriously reducing the steaming rate.

The ratio of heating surface to grate area is above the average for boilers of this type.

Many other characteristics of this boiler are described in a booklet. Please write for a copy for your file.

In addition to the two types illustrated above, we build the Up-Draft type for low volatile coals, which does not have the water cooled hanging arch as built into the smokeless type and is, therefore, slightly lower in price.

SIZES, WEIGHTS, CAPACITIES, ETC.

SERIES NO. 3—SMOKELESS FOR COAL

No.	Heating Surface Sq. Ft.	Grate Area Sq. Ft.	Capacity Steam Sq. Ft.	Hot Water Capacity Sq. Ft.	Shipping Weight Pounds
352	259	13.1	3500	5775	6500
353	301	13.1	4000	6600	7000
354	343	14.6	4500	7425	7500
355	375	16.3	5000	8250	8000
356	409	17.9	5500	9075	8500
357	449	17.9	6000	9900	9000
358	523	19.7	7000	11550	9800
359	600	22	8000	13200	10800
360	680	22	9000	14850	11750
361	803	24	10500	17325	13300
362	914	27	12000	19800	14650
363	1071	29.3	14000	23100	16500
364	1222	31.5	16000	26400	18500
365	1372	31.5	18000	29700	20500
366	1533	34.1	20000	33000	22400
367	1686	35.5	22000	36300	24300
368	1927	38.5	25000	41250	27250
369	2153	41.5	28000	46200	30000

SERIES NO. 4—FOR OIL, GAS OR STOKER

No.	Heating Surface Sq. Ft.	Capacity Steam Sq. Ft.	Hot Water Capacity Sq. Ft.	Shipping Weight Pounds
452	259	4500	7425	5341
453	301	5250	8663	5800
454	343	5500	9075	6183
455	375	6250	10313	6632
456	409	6750	11138	7009
457	449	7250	11963	7484
458	523	8250	13613	8145
459	600	9500	15675	9026
460	680	10500	17325	9938
461	803	12500	20625	11324
462	914	14000	23100	12077
463	1071	16200	26730	13705
464	1222	18200	30030	15573
465	1372	20500	33825	17500
466	1533	22700	37455	19191
467	1686	25000	41250	21058
468	1927	28200	46250	23746
469	2153	31700	52305	25954

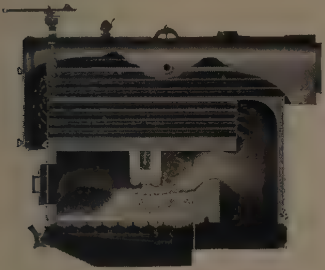
Send for Booklets and Price List

Heggie-Simplex Boiler Co.

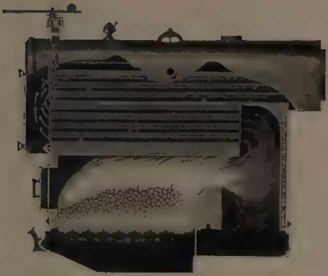
Joliet, Illinois

Heating Boiler Division of James G. Heggie & Sons, Manufacturers of Steel Boilers for Over 38 Years

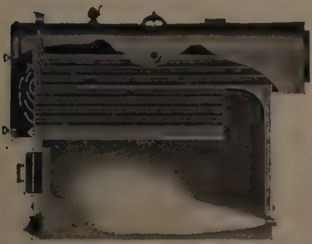
Representatives in Principal Cities



For Burning Soft Coal Smokelessly



For Soft or Hard Coal, Coke, or Wood



For Burning Oil or Gas

The introduction of Heggie-Simplex Boilers marked the beginning of a new era in heating boiler design and construction. While widely imitated today, they embody the simplicity in design upon which the durability, that has made them so popular, depends. Patents protect this superiority.

The crown and side walls of the firebox and auxiliary combustion chamber are made from a single plate—there are fewer plates, and fewer seams in Heggie-Simplex Boilers than in other boilers of this popular type.

While built to conform with the A. S. M. E. Code, its requirements are minimum only in Heggie-Simplex specifications. For example, where the Code calls for $\frac{1}{4}$ in plate, Heggie-Simplex employ $\frac{5}{16}$ in. All openings are reinforced with forged steel flanges. Bases are made of steel channels. Similarly, every detail affecting greater strength and longer life is incorporated.

S. H. B. I. Ratings

Heggie-Simplex Boilers are rated in conformity with the "Steel Heating Boiler Institute's Code for Rating Low Pressure Heating Boilers."

These ratings are **the total radiation load at the boiler outlet;** expressed in square feet of cast iron radiation. Steam ratings are based upon the emission of 240 B.t.u. per hour per square foot of rating at 2 lb. pressure. Water ratings are based upon the emission of 150 B.t.u. per hour per square foot of rating at 180 deg. fahr.

To determine the Heggie-Simplex Boiler required to heat a building, add the following: (1) the direct radiation, (2) the equivalent to compensate for losses through water heaters or other apparatus connected to the boiler, (3) and the equivalent to compensate for losses through piping connecting the radiation, water heater and other apparatus to the boiler. Then select a size with a rating equal to this total load.

Send for catalog to obtain more detailed information and specifications.

HEGGIE-SIMPLEX STEEL HEATING BOILERS—STEAM AND WATER

Boiler No.—Smokeless, Steam	134-A	134-C	134-E	140-A	140-B	140-D	140-E	147-A	147-B	147-C	152-A	152-B	152-C	152-D	157-A
Boiler No.—Direct Draft, Steam	334-A	334-C	334-E	340-A	340-B	340-D	340-E	347-A	347-B	347-C	352-A	352-B	352-C	352-D	357-A
Steam Rating ... sq. ft.	1690	2110	2530	3110	3500	4120	4510	5010	5490	5960	6500	7000	7520	8040	9100
Boiler No.—Oil, Gas, or Stoker Fired, Steam	734-A	734-C	734-E	740-A	740-B	740-D	740-E	747-A	747-B	747-C	752-A	752-B	752-C	752-D	757-A
Steam Rating ... sq. ft.	2060	2570	3080	3770	4250	5000	5470	6090	6660	7240	7890	8500	9130	9760	11050
Boiler No.—Smokeless, Water*	234-A	234-C	234-E	240-A	240-B	240-D	240-E	247-A	247-B	247-C	252-A	252-B	252-C	252-D	257-A
Boiler No.—Direct Draft, Water*	434-A	434-C	434-E	440-A	440-B	440-D	440-E	447-A	447-B	447-C	452-A	452-B	452-C	452-D	457-A
Water Rating ... sq. ft.	2700	3380	4050	4980	5600	6590	7220	8020	8780	9540	10400	11200	12030	12860	14560
Boiler No.—Oil, Gas, or Stoker Fired, Water*	834-A	834-C	834-E	840-A	840-B	840-D	840-E	847-A	847-B	847-C	852-A	852-B	852-C	852-D	857-A
Water Rating ... sq. ft.	3300	4110	4930	6030	6800	8000	8750	9740	10660	11580	12620	13600	14610	15620	17680
Heating Surface ... sq. ft.	121	151	181	222	250	294	322	358	392	426	464	500	537	574	650
Grate Area ... sq. ft.	8.2	10.3	10.4	12.1	13.7	13.7	13.7	14.7	16.5	16.5	18.6	18.6	20.7	20.7	22.9
Height of Water Line ... in.	62¼	62¼	62¼	69¼	69¼	69¼	69¼	72½	72½	72½	78⅝	78⅝	78⅝	78⅝	81⅜
Height of Boiler ... in.	72	72	72	79	79	79	79	86	86	86	91	91	91	91	97
Width of Boiler ... in.	34	34	34	40	40	40	40	47	47	47	52	52	52	52	57
Length of Boiler ... in.	67¼	79¼	91¼	80¼	86¼	98¼	104¼	101¼	107¼	113¼	103¼	109¼	115¼	121¼	115¼
Diameter of Breeching ... in.	20	20	20	22	22	22	22	24	24	24	26	26	26	26	28
Diameter of Stack ... in.	18	18	18	20	20	20	20	22	22	22	24	24	24	24	26
Minimum Height of Stack ... ft.	55	55	55	60	60	60	60	65	65	65	70	70	70	70	75
Diameter of Breeching 2 Boilers ... in.	28	28	28	30	30	30	30	34	34	34	38	38	38	38	40
Diameter of Stack—2 Boilers ... in.	26	26	26	28	28	28	28	32	32	32	34	34	34	34	36
Minimum Height of Stack—2 Boilers ... ft.	65	65	65	70	70	70	70	75	75	75	80	80	80	80	85
Size of Steam Outlet ... in.	6	6	6	6	6	6	6	8	8	8	8	8	8	8	8
Size of Return ... in.	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4
Boiler Covering Required ... sq. ft.	66	78	89	92	98	110	116	125	133	141	136	144	152	160	167

Boiler No.—Smokeless, Steam	157-C	157-D	163-A	163-B	163-C	163-D	170-A	170-B	170-C	178-A	178-C	184-A	184-C	184-E	184-G
Boiler No.—Direct Draft, Steam	357-C	357-D	363-A	363-B	363-C	363-D	370-A	370-B	370-C	378-A	378-C	384-A	384-C	384-E	384-G
Steam Rating ... sq. ft.	10420	11070	12520	13360	14200	15040	16020	17020	18030	20010	22390	25000	28010	31010	34010
Boiler No.—Oil, Gas, or Stoker Fired, Steam	757-C	757-D	763-A	763-B	763-C	763-D	770-A	770-B	770-C	778-A	778-C	784-A	784-C	784-E	784-G
Steam Rating ... sq. ft.	12650	13450	15200	16220	17240	18260	19450	20670	21900	24290	27180	30360	34020	37660	41290
Boiler No.—Smokeless, Water*	257-C	257-D	263-A	263-B	263-C	263-D	270-A	270-B	270-C	278-A	278-C	284-A	284-C	284-E	284-G
Boiler No.—Direct Draft, Water*	457-C	457-D	463-A	463-B	463-C	463-D	470-A	470-B	470-C	478-A	478-C	484-A	484-C	484-E	484-G
Water Rating ... sq. ft.	16670	17710	20030	21380	22720	24060	25630	27230	28850	32020	35820	40000	44820	49620	54420
Boiler No.—Oil, Gas, or Stoker Fired, Water*	857-C	857-D	863-A	863-B	863-C	863-D	870-A	870-B	870-C	878-A	878-C	884-A	884-C	884-E	884-G
Water Rating ... sq. ft.	20240	21520	24320	25950	27580	29220	31120	33070	35040	38860	43490	48576	54430	60260	66060
Heating Surface ... sq. ft.	744	791	894	954	1014	1074	1144	1216	1288	1429	1599	1786	2001	2215	2429
Grate Area ... sq. ft.	22.9	25.2	25.5	28.1	28.1	30.6	31.0	31.0	33.9	35.0	38.2	38.0	41.3	44.8	44.8
Height of Water Line ... in.	81⅜	81⅜	93	93	93	93	96¼	96¼	96¼	106¼	106¼	113⅛	113⅛	113⅛	113⅛
Height of Boiler ... in.	97	97	108	108	108	108	116	116	116	126	126	132	132	132	132
Width of Boiler ... in.	57	57	63	63	63	63	70	70	70	78	78	84	84	84	84
Length of Boiler ... in.	127¼	133¼	123¼	129¼	135¼	141¼	129¼	135¼	141¼	135¼	147¼	141¼	153¼	165¼	177¼
Diameter of Breeching ... in.	28	28	30	30	30	30	34	34	34	38	38	42	42	42	42
Diameter of Stack ... in.	26	26	28	28	28	28	32	32	32	36	36	40	40	40	40
Minimum Height of Stack ... ft.	75	75	75	75	75	75	80	80	80	90	90	100	100	100	100
Diameter of Breeching 2 Boilers ... in.	40	40	44	44	44	44	50	50	50	54	54	56	56	56	56
Diameter of Stack—2 Boilers ... in.	36	36	40	40	40	40	46	46	46	50	50	54	54	54	54
Minimum Height of Stack—2 Boilers ... ft.	85	85	85	85	85	85	90	90	90	100	100	110	110	110	110
Size of Steam Outlet ... in.	8	8	10	10	10	10	10	10	10	10	10	10	10	10	10
Size of Return ... in.	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5
Boiler Covering Required ... sq. ft.	184	193	197	206	215	224	230	240	250	258	281	291	314	337	361

*Supply outlets and return openings on Water Boilers—furnished as specified on contractor's order, in sizes 2, 3, 4, 5, 6, 8 and 10 in.

Heggie-Simplex Jacketed Steel Boilers Establish New Standard in Residence Heating

The same practical advantages that have made *steel* boilers the accepted standard in large buildings, now are available for houses and small buildings in the Heggie-Simplex Jacketed Boiler—at prices well within everyone's means.

It is built of steel, electrically welded. Thus, the danger of cracking, inherent in more brittle material, is avoided; and continuous, leak-proof service is assured.

Its large fuel capacity insures long firing periods. Its spacious firebox, large amount of direct heating surface, tubular flues, free circulation, and deep steam space afford unparalleled efficiency. It is economical and equally as well adapted to hard coal, soft coal, coke, gas or oil; and to hand or mechanical firing.

This modern boiler is simple and inexpensive to install. Ranging from 24 to 30 in. wide, even the largest size goes through any door. There are no sections to join, no headers to connect, no packing or other costly assembling operations.

Heggie-Simplex Jacketed Boilers are rated in conformity with the "Steel Heating Boiler Institute's Code for Rating Low Pressure Heating Boilers." They will not only develop these ratings but are warranted capable of handling substantial overloads with ease.

HEGGIE-SIMPLEX JACKETED BOILERS
For Hard Coal or Coke, and for Oil, Gas or Stoker Firing†

Boiler No. With Jacket	Steam Rating Hard Coal or Coke	Boiler No. With Jacket	Steam Rating Oil, Gas or Stoker Firing	Boiler No. With Jacket	Water Rating Hard Coal or Coke	Boiler No. With Jacket	Water Rating Oil, Gas or Stoker Firing	Heating Surface Sq. Ft.	Grate Area Sq. Ft.	Diam. Stack Req'd In.	Height Stack Req'd Ft.	Size* Outlet In.	Size* Return In.
2SJ1	370	2SCJ1	540	2WJ1	590	2WCJ1	860	32	2.6	10	30	3	3
2SJ2	510	2SCJ2	680	2WJ2	820	2WCJ2	1090	40	3.5	10	30	3	3
2SJ3	670	2SCJ3	820	2WJ3	1070	2WCJ3	1310	48	4.3	10	30	3	3
2SJ4	800	2SCJ4	970	2WJ4	1280	2WCJ4	1550	57	5.1	10	30	3	3
2SJ5	950	2SCJ5	1160	2WJ5	1490	2WCJ5	1860	68	5.8	12	40	4	4
2SJ6	1110	2SCJ6	1340	2WJ6	1780	2WCJ6	2140	79	6.0	12	40	4	4
2SJ7	1300	2SCJ7	1580	2WJ7	2080	2WCJ7	2530	93	7.0	12	40	4	4
2SJ8	1480	2SCJ8	1800	2WJ8	2370	2WCJ8	2880	106	7.8	12	40	4	4
2SJ9	1620	2SCJ9	1970	2WJ9	2590	2WCJ9	3150	116	7.9	14	50	5	5
2SJ10	1830	2SCJ10	2230	2WJ10	2930	2WCJ10	3570	131	9.0	14	50	5	5

*One Outlet and Return Opening furnished with Water Boilers, unless otherwise specified; two of each supplied on request without additional charge.

†Equipped with 2 in. flues.

For Soft Coal‡

Boiler No. With Jacket	Steam Rating Soft Coal	Boiler No. With Jacket	Water Rating Soft Coal	Heating Surface Sq. Ft.	Grate Area Sq. Ft.	Diameter Stack Required In.	Height Stack Required Ft.	Size* Outlet In.	Size* Return In.
3SJ1	370	3WJ1	590	30	2.6	10	30	3	3
3SJ2	510	3WJ2	820	38	3.5	10	30	3	3
3SJ3	630	3WJ3	1010	45	4.3	10	30	3	3
3SJ4	740	3WJ4	1180	53	5.1	10	30	3	3
3SJ5	840	3WJ5	1340	60	5.8	12	40	4	4
3SJ6	980	3WJ6	1570	70	6.0	12	40	4	4
3SJ7	1160	3WJ7	1860	83	7.0	12	40	4	4
3SJ8	1300	3WJ8	2080	93	7.8	12	40	4	4
3SJ9	1370	3WJ9	2180	98	7.9	14	50	5	5
3SJ10	1570	3WJ10	2510	112	9.0	14	50	5	5

*One Outlet and Return Opening furnished with Water Boilers, unless otherwise specified; two of each supplied on request without additional charge.

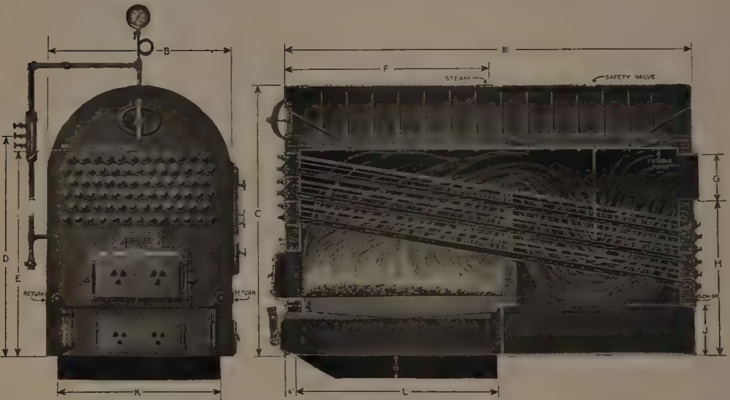
‡Equipped with 3 in. flues.

Harrisburg Star Boiler Corporation

15 Park Row, New York

LOW PRESSURE WATER TUBE HEATING BOILERS

A.S.M.E. Code



Standard Equipment consists of Shaking and Dumping Grates, Steel Base, Low Pressure Steam Gage with Siphon, Cast Iron Water Column with gage glass and three brass try-cocks, Pop Safety Valves as required, Cleaning Brush, Tube Scraper, Hoe, Poker and Slice Bar.

(Boilers Nos. 704 to 718 inclusive, require no brick work of any kind. Boilers Nos. 719 to 725 inclusive, require brick bridgewalls.)

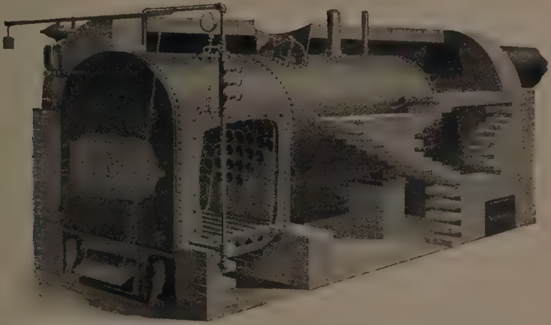
Boiler Number	Steam, Capacity, Sq. Ft.	Water Evaporation, Lbs.	Grate Surface, Sq. Ft.	"A" Total Length, Ft.	"B" Total Width, In.	"C" Total Height, Ft.	"D" Water Line, In.	"G" Size Smoke Flue	"J" Height of Base	"K" Width Ash Pit	"L" Length Ash Pit	Diameter Stack One Boiler, In.	Height Stack One Boiler, Ft.	Diameter Stack Two Boilers, In.	Height Stack Two Boilers, Ft.	Brick Required for Base	Asbestos Cover, Sq. Ft.	Approx. Weight Boiler Complete
704	2750	690	9.4	7–9	39	5–5	56	10x26	15	2–8	3–8	18	50	23	50	None	76	5500
705	3450	862	10.6	7–0	43	6–0	61	13x22	15	3–0	3–8	18	50	24	50	"	77	6800
706	4150	1035	12.1	8–3	43	6–0	61	13x28	15	3–0	4–2	18	60	25	60	"	91	7300
707	5000	1242	14.8	8–3	52	6–4	63	13x31	15	3–8	4–2	20	60	27	60	"	99	8000
708	5800	1449	14.8	8–3	52	6–7	66	13x31	15	3–8	4–2	21	60	29	65	"	103	9000
709	6900	1725	18.3	9–1	56	6–8	68	13x38	15	4–0	4–8	23	60	31	65	"	118	10700
710	8300	2070	20.3	10–10	56	6–8	68	13x42	15	4–0	5–2	25	60	33	70	"	141	11300
711	9000	2242	21.8	10–10	60	6–11	69	16x36	15	4–4	5–2	25	65	34	70	"	148	11700
712	9700	2415	24.0	11–7	60	6–11	69	16x39	15	4–4	5–8	26	65	35	70	"	160	12000
713	10400	2587	26.2	12–5	60	6–11	69	16x43	15	4–4	6–2	26	65	36	70	"	171	12500
713 A	11000	2760	26.2	11–7	60	7–3	73	19x36	15	4–4	6–2	27	70	36	75	"	167	12800
714	11700	2932	28.3	12–6	60	7–3	73	19x39	15	4–4	6–8	28	70	37	75	"	178	13300
715	12400	3105	30.5	13–1	60	7–3	73	19x42	15	4–4	7–2	29	70	38	75	"	188	14000
716	13800	3450	31.8	11–10	71	7–11	76	19x43	15	5–3	6–3	30	70	40	80	"	193	15500
717	15200	3795	34.4	12–11	71	7–11	76	19x47	15	5–3	6–9	31	70	42	80	"	208	16800
718	17300	4312	37.0	14–7	71	7–11	76	19x50	15	5–3	7–3	32	80	43	90	"	234	18500
719	18600	4657	41.3	12–6	90	9–1	83	21x46	18	6–10	6–3	33	85	44	90	"	244	20000
720	20700	5175	44.7	13–10	90	9–1	83	21x51	18	6–10	6–9	34	90	46	100	"	260	21000
721	24200	6037	51.0	16–1	90	9–1	83	21x61	18	6–10	7–9	36	100	48	110	"	304	25200
722	27600	6900	55.4	14–1	103	10–2	90	21x66	18	7–11	7–3	38	100	51	110	"	302	27700
723	31600	7762	55.4	14–1	103	10–6	94	21x66	18	7–11	7–3	39	110	52	110	"	312	29300
724	35000	8625	59.4	15–9	103	10–6	94	21x71	18	7–11	7–9	40	110	54	110	"	351	32700
725	42000	10350	63.3	17–2	103	10–10	98	21x76	18	7–11	8–3	42	110	60	110	"	394	35600

Kewanee Boiler Corporation

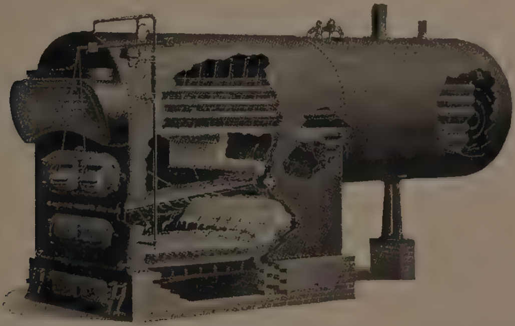
Kewanee, Illinois

BRANCHES IN 33 PRINCIPAL CITIES

Steel Heating and Power Boilers, Water Heating Garbage Burners, Tabasco Heaters, Tanks and Radiators



KEWANEE FIREBOX BOILER—*Brick-set—for Heating* Kewanee Firebox Boilers represent 45 years of intensive study and effort to make the highest grade equipment for heating buildings. They are adapted to the burning of any grade of fuel and will maintain high efficiency when operating to supply the variable demands of a heating load.



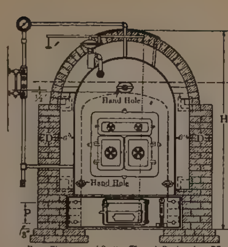
KEWANEE SMOKELESS BOILER—*Portable—for Heating* The rated capacity is the amount of direct radiation that the boiler will carry with a firing interval of three to four hours depending upon the grade of fuel used. No discount in rating is advised as reserve capacity has been allowed to care for the most severe weather conditions.

Kewanee Boilers are all built of steel using as a minimum basis the rules of construction adopted by the *American Society of Mechanical Engineers*, known as the *A. S. M. E.* Boiler Code.

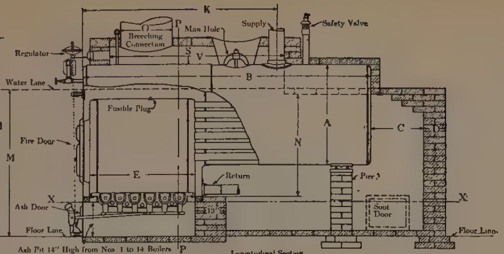
Ratings

The rated capacity of Kewanee Boilers, as shown, is the number of square feet of direct radiation or equivalent which the boiler will carry, if sufficient radiation is installed to heat the building to 70 degrees Fahrenheit.

The ratings are based on a standard for steam of 2 lb. pressure at the boiler, and for water on a mean temperature of 180 deg. Fahr. as the water leaves the boiler.

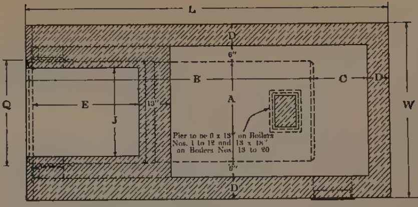


Front Elevation and Section Through Brickwork at PP



Ash Pit 14" High from Nos 1 to 14 Boilers and 17" from Nos 15 to 20 Boilers

Longitudinal Section

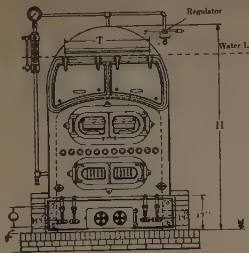

L
W
Q
E
J
B
A
C
D
D
D
6"
6"
13"
Pier to be 9 x 13" on Boilers Nos. 1 to 12 and 13 x 18" on Boilers Nos. 13 to 20

Foundation Plan at XX

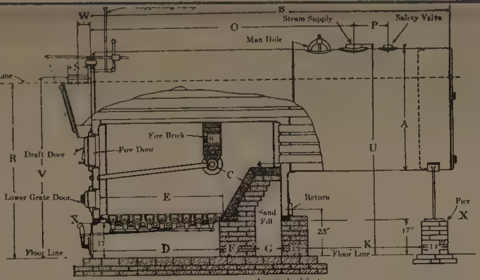
KEWANEE FIREBOX BOILERS—BRICK-SET TYPE

Number of Boiler	0	1	2	3	4	5	6	8	9	10	11	12	13	14	15	16	17	18	19	20
Capacity, Steam . . . sq. ft.	700	900	1050	1200	1400	1700	2000	2600	3000	3500	4000	4500	5500	6500	7500	8700	10000	11000	12000	14000
A—Diameter of Boiler . . . in.	24	30	30	30	36	36	36	42	42	48	48	48	54	54	60	60	66	66	72	72
B—Length of Boiler . . . ft.	7	6½	7½	8½	7½	9	10½	10	11½	10½	12	13½	14	16½	15½	18	16	18	16	18
Heating Surface . . . sq. ft.	84	113	131	147	180	215	250	305	350	368	420	472	560	673	743	873	954	1080	1167	1329
Area of Grate . . . sq. ft.	3.5	4.4	5.4	6.4	6.8	8.0	9.3	11.1	12.6	12.9	14.7	16.5	18.8	20.8	22.9	25.1	25.5	28.0	30.8	33.5
Diameter of Breeching . . . in.	10	12	14	16	16	18	18	20	22	22	24	24	28	28	32	32	32	32	36	36
Diameter of Stack . . . in.	10	12	12	14	14	16	16	18	20	20	22	22	26	26	30	30	30	30	34	34
Minimum Height of Stack . . . ft.	35	40	40	40	40	40	45	45	45	45	50	50	50	50	55	55	60	60	60	60
Diameter of Breeching, Two Boilers . . . in.	16	18	20	22	22	24	24	28	32	32	32	34	36	36	40	40	40	42	44	46
Diameter of Stack, Two Boilers . . . in.	16	18	18	20	20	22	22	26	28	28	30	32	34	34	36	36	36	38	40	42
Minimum Height of Stack, Two Boilers . . . ft.	40	45	45	45	45	45	45	50	50	50	50	50	55	60	60	70	70	70	70	70
Size of Steam Opening . . . in.	3	4	4	5	5	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8
Size of Return . . . in.	2	2½	2½	3	3	3	3	4	4	4	4	5	5	5	5	5	6	6	6	6
Size of Safety Valve . . . in.	1	1¼	1¼	1¼	1½	1½	2	2	2	2	2½	2½	2½	3	3	3½	3½	3½	4	4
C—Rear Space . . . in.	14	17	17	17	17	17	17	22	22	22	22	22	24	24	24	24	24	24	28	28
D—Thickness Wall . . . in.	9	9	9	9	9	9	9	9	9	9	9	9	13	13	13	13	13	13	13	13
E—Length Grate . . . in.	26	26	32	38	32	38	44	44	50	44	50	56	56	62	62	68	62	68	68	74
J—Width Ash-pit . . . in.	19	25	25	25	31	31	31	37	37	43	43	43	49	49	54	54	60	60	66	66
H—Total Height . . . in.	64	70	70	70	77	77	77	83	83	90	90	90	96	96	108	108	114	114	120	120
K—Location of Supply . . . ft. in.	4-0	4-0	4-8	5-6	4-11	5-11	6-11	6-8	7-2	7-0	7-10	8-6	9-2	9-8	9-6	10-8	9-8	10-8	9-9	10-9
M—Height of Water-line . . . in.	47	52	52	52	55	55	55	58½	58½	61	61	61	66	66	75	75	80	80	85½	85½
N—Height of Side Flue . . . ft. in.	2-6	2-8	2-8	2-8	3-0	3-0	3-0	3-3	3-3	3-6	3-6	3-6	4-0	4-0	4-3	4-3	4-10	4-10	5-3	5-3
O—Diameter Breeching Connection . . . in.	10	12	14	16	16	18	18	20	22	22	24	24	28	28	32	32	32	32	36	36
S—Top Flue Space . . . in.	6	6	6	6	7	7	7	7	7	8	8	8	8	8	10	10	10	10	10	10
V—Length of Arch . . . ft. in.	3-2	3-2	3-10	4-9	4-1	5-1	6-1	6-3	6-9	6-3	7-3	7-9	8-1	8-7	8-5	9-7	8-7	9-8	8-9	9-9
P—Anchor Bolt Centers for Ash-pit Front . . in.	8	8	8	8	8	8	8	8	8	8	8	8	8	8	11	11	11	11	11	11
Q—Anchor Bolt Centers for Ash-pit Front . . in.	24	30	30	30	36	36	36	42	42	48	48	48	54	54	60	60	66	66	72	72
L—Total Length Over-all . . . ft. in.	8-8	8-7	9-8	10-8	9-8	11-2	12-8	12-7	14-1	13-1	14-7	16-1	17-0	19-6	18-7	21-1	19-1	21-1	19-5	21-5
W—Total Width Over-all . . . ft. in.	4-6	5-0	5-0	5-0	5-6	5-6	5-6	6-0	6-0	6-6	6-6	6-6	7-8	7-8	8-2	8-2	8-8	8-8	9-2	9-2
*Number of Common Brick . . .	1325	1450	1600	1750	1900	2150	2400	2650	2900	3000	3300	3600	5300	5900	6500	7200	7200	7700	7700	8200
*Common Brick for Two Boilers . . .	2250	2450	2700	2950	3300	3750	4100	4750	5350	5400	5900	6450	8350	10350	11350	12550	12400	13450	13250	13850

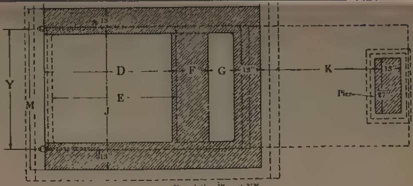
Note—A Firing Space of about 8'-0" should be maintained at front of Boilers. This provides sufficient space to draw tubes through firedoor,



Front Elevation



Longitudinal Section

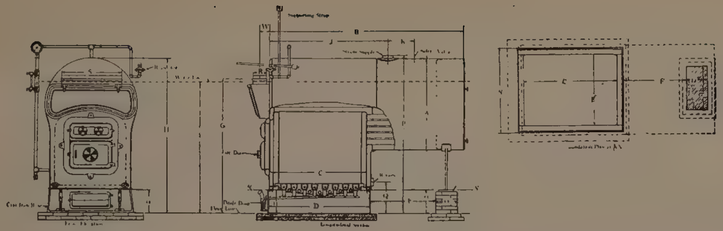


Foundation Plan at XX

KEWANEE SMOKELESS BOILERS—PORTABLE TYPE

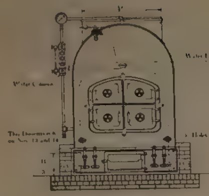
Number of Boiler	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324
Capacity, Steam . . . sq. ft.	3000	3500	4000	4500	5000	5500	6000	6500	7500	8500	10000	12000	14000	16000	18000	20000	25000	30000
Heating Surface . . . sq. ft.	297	352	391	446	496	546	592	643	721	773	912	1053	1204	1316	1458	1549	2074	2629
Area of Upper Grate . . . sq. ft.	8.8	10.1	11.4	12.9	14.7	16.5	17.1	18.5	20.0	21.4	23.5	25.9	28.5	29.9	32.6	34.6	41.7	44.8
A—Diameter of Boiler . . . in.	48	48	48	54	54	54	60	60	60	60	66	66	72	72	78	78	84	84
B—Length of Boiler Over-all . . . ft. in.	9-1	10-5	11-5	10-11	11-11	12-11	12-11	13-11	15-3	16-3	15-9	17-9	16-7	17-11	17-10	18-10	20-1	24-1
Diameter of Stack . . . in.	20	20	20	22	22	22	24	24	26	26	28	30	32	32	34	34	38	40
Minimum Height of Stack . . . ft.	50	55	55	55	55	60	60	60	65	65	65	70	70	70	80	90	90	100
Diameter of Stack, Two Boilers . . . in.	28	28	28	31	31	31	34	34	36	36	40	42	46	46	48	48	54	54
Minimum Height of Stack, Two Boilers . . . ft.	60	65	65	65	65	70	70	70	75	75	75	80	80	80	90	100	100	110
Size of Steam Opening . . . in.	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8	8	10	10
Size of Return . . . in.	4	4	4	4	4	4	5	5	5	5	6	6	6	6	6	6	6	6
Size of Safety Valve . . . in.	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	2-2½	2-3	2-3	2-3½
Distance Required to Open Rear Flue Doors . . . in.	26	26	26	28	28	28	32	32	32	32	35	35	37	37	40	40	43	43
E—Length Grate . . . in.	37	43	49	49	55	61	55	61	61	67	61	67	67	73	73	73	79	85
C—Header to Bridge Wall . . . in.	9	10	11½	11	12½	14	12½	14	14	15	15	16	16	17	17	18	18	19
D—Length Ash-pit . . . in.	38	44	50	50	56	62	56	62	63	69	63	69	69	75	75	75	81	87
K—Rear Wall to Pier . . . in.	29	39	45	27	33	39	45	51	57	63	62	80	63	74	72	79	84	126
J—Width Ash-pit . . . in.	37	37	37	43	43	43	49	49	53	53	59	59	65	65	71	71	77	77
M—Width Foundation . . . in.	46	46	46	60	60	60	66	66	79	79	85	85	91	91	97	97	103	103
L—Length Foundation . . . in.	61	67	73	84	90	96	90	96	107	113	107	113	113	119	119	125	131	137
H—Height Boiler . . . in.	84	84	84	89	89	89	98	98	101	101	107	107	113	113	115	115	121	121
U—Height Supply . . . in.	85	85	85	90	90	90	99	99	103	103	109	109	115	115	117	117	123	123
R—Height Water-line . . . in.	71	71	71	76	76	76	83	83	87	87	90	90	96	96	97	97	105	105
V—Height of Breeching Connection . . . in.	76	76	76	80	80	80	88	88	90	90	93	93	100	100	101	101	109	109
O—Location Supply . . . ft. in.	5-11	6-8	7-3	7-6	8-2	8-9	8-9	9-3	10-11	11-6	11-0	11-9	11-7	12-2	12-2	12-9	13-8	15-0
P—Location Safety Valve . . . in.	12	14	14	13	13	15	15	18	16	18	16	18	15	18	18	16	18	20
W—Center Breeching Connection to Front of Boiler . in.	8	8	8	8	8	8	9¼	9¼	9¼	9¼	10½	10½	11½	11½	11½	11½	13	13
S—Width Breeching Connection . . . in.	10	10	10	10	10	10	12½	12½	12½	12½	15	15	17	17	17	17	20	20
T—Length Breeching Connection . . . in.	36	36	36	42	42	42	46	46	46	46	50	50	54	54	60	60	64	64
†Req'd at Front to Draw Tubes . . . ft. in.	7-7	8-11	9-11	9-5	10-5	11-5	11-5	12-5	13-8	14-8	14-0	16-0	14-8	16-0	16-0	17-0	18-0	22-0
†Req'd at Rear to Draw Tubes . . . ft in.	6-0	7-4	8-4	7-10	8-10	9-10	9-10	10-10	12-2	13-2	12-4	14-4	12-10	14-2	14-1	15-1	16-0	20-0
*Number Common Brick . . .	200	200	200	800	825	850	1025	1050	1300	1350	1300	1350	1375	1450	1400	1475	1575	1600
Number Fire Brick . . .	115	115	115	155	155	155	195	195	210	215	240	240	255	255	290	315	425	425
Outside Surface to be Covered . . . sq. ft.	148	157	173	184	212	221	255	265	266	280	290	330	335	360	370	400	455	545

KEWANEE FIREBOX BOILERS—PORTABLE TYPE

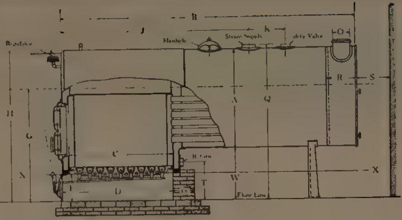


Number of Boiler	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424
Capacity, Steam sq. ft.	2500	2900	3500	4000	4500	5000	5500	6000	7000	8000	9500	11000	13000	15000	17500	20000	25000	28000
Heating Surface sq. ft.	278	310	373	416	465	515	565	626	676	778	929	1040	1168	1303	1514	1711	2209	2427
Area of Grate sq. ft.	9.6	11.1	12.6	12.9	14.7	16.5	18.8	20.8	20.7	22.9	25.5	28.0	30.8	33.5	36.6	39.6	42.9	46.1
A—Diameter of Boiler in.	48	48	48	54	54	54	60	60	60	60	66	66	72	72	78	78	84	84
B—Length of Boiler ft. in.	8-7	9-6	11-1	10-0	11-1	12-1	12-5	13-7	14-4	16-2	15-9	17-4	15-11	17-6	17-11	19-11	20-1	22-1
Diameter of Stack in.	20	20	20	22	22	22	24	24	26	26	28	30	32	32	34	34	38	40
Minimum Height of Stack ft.	50	50	55	55	55	60	60	60	65	65	65	70	70	70	80	90	90	100
Diameter of Stack, Two Boilers in.	28	28	28	31	31	31	34	34	36	36	40	42	46	46	48	48	54	54
Minimum Height of Stack, Two Boilers ft.	60	60	65	65	65	70	70	70	75	75	75	80	80	80	90	100	100	110
Size of Steam Opening in.	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8	8	10	10
Size of Return in.	4	4	4	4	4	4	5	5	5	5	6	6	6	6	6	6	6	6
Size of Safety Valve in.	2	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	2-2½	2-3	2-3	2-3
Distance Required to Open Rear Flue Doors in.	26	26	26	28	28	28	32	32	32	32	35	35	37	37	40	40	43	43
C—Length of Fire-box in.	38	44	50	44	50	56	56	62	56	62	62	68	68	74	74	80	80	86
D—Length of Ash-pit in.	45	51	57	47	53	59	59	65	60	66	66	72	72	78	78	84	84	90
E—Width of Fire-box in.	36	36	36	43	43	43	49	49	53	53	59	59	65	65	71	71	77	77
F—Ash-pit Base to Pier ft. in.	3-3	3-8	4-9	3-9	4-4	4-10	5-2	5-10	6-7	7-11	7-5	8-5	6-11	7-11	8-4	9-10	9-10	11-4
G—Height Breeching Connection in.	76	76	76	80	80	80	88	88	90	90	93	93	100	100	101	101	109	109
H—Height of Boiler in.	84	84	84	89	89	89	98	98	101	101	107	107	113	113	115	115	121	121
P—Height of Steam Supply in.	85	85	85	90	90	90	99	99	103	103	109	109	115	115	117	117	123	123
L—Height of Water-line in.	71	71	71	76	76	76	83	83	87	87	90	90	96	96	97	97	105	105
J—Location of Steam Supply ft. in.	4-8	5-3	6-3	5-6	6-4	8-0	8-3	8-8	8-5	9-5	9-4	10-2	9-8	11-1	11-3	12-0	12-6	12-6
K—Location of Safety Valve in.	13	14	18	16	18	13	16	18	21	29	18	32	18	26	24	30	24	21
W—Center of Breeching Connection to Front of Boiler in.	8	8	8	8	8	8	9¼	9¼	9¼	9¼	10½	10½	11½	11½	11½	11½	13	13
R—Width Breeching Connection in.	10	10	10	10	10	10	12½	12½	12½	12½	15	15	17	17	17	17	20	20
S—Length Breeching Connection in.	36	36	36	42	42	42	46	46	46	46	50	50	54	54	60	60	64	64
†Req'd at Front to Draw Tubes ft. in.	7-1	8-0	9-7	8-7	9-7	10-7	11-0	12-2	12-10	14-8	14-1	15-8	14-1	15-8	16-1	18-1	18-1	20-1
†Req'd at Rear to Draw Tubes ft. in.	5-6	6-5	8-0	6-11	7-11	8-11	9-4	10-6	11-3	13-1	12-4	13-11	12-2	13-9	14-2	16-2	16-2	18-2
*Number Common Brick	70	70	70	450	480	510	530	560	680	710	740	760	790	820	840	885	900	935
Outside Surface to be Covered sq. ft.	115	130	150	155	175	185	190	220	250	280	290	310	315	345	385	425	455	505

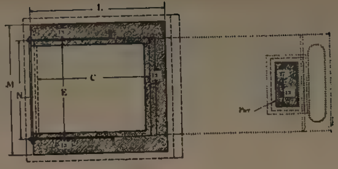
*Foundations not included. †If space is available at front, it is not necessary at rear, and vice-versa.



Front Elevation



Longitudinal Section

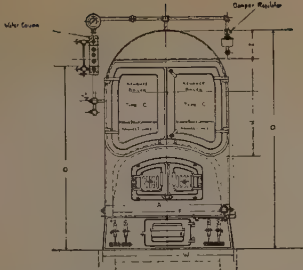


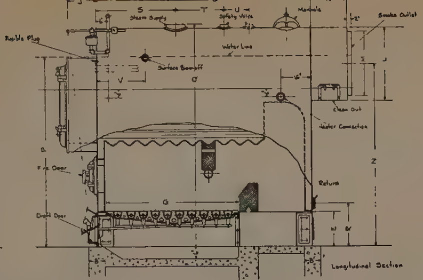
Foundation Plan at X X

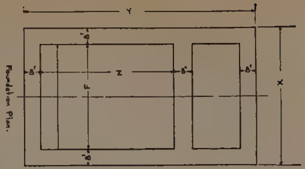
KEWANEE BOILERS PORTABLE TYPE K—UP-DRAFT

Number of Boiler	0K	1K	2K	3K	4K	5K	6K	8K	9K	10K	11K	12K	13K	14K	15K	16K	17K	18K	19K	20K
Capacity, Steam. sq. ft.	600	850	1000	1150	1300	1600	1900	2450	2850	3300	3800	4300	5200	6200	7100	8200	9500	10400	11400	13300
Heating Surface. sq. ft.	61	83	93	104	139	164	190	241	275	298	338	378	447	537	603	708	791	896	992	1129
Area of Grate. sq. ft.	3.5	4.4	5.4	6.4	6.8	8.0	9.3	11.1	12.6	12.9	14.7	16.5	18.8	20.8	22.9	25.1	25.5	28.0	30.8	33.5
A—Diameter of Boiler. in.	24	30	30	30	36	36	36	42	42	48	48	48	54	54	60	60	66	66	72	72
B—Length of Boiler Over-all. ft. in.	7-9	7-10	8-10	9-10	8-10	10-4	11-10	11-4	12-10	11-10	13-4	14-10	15-4	17-10	17-0	19-6	17-6	19-6	17-6	19-6
Diameter of Stack. in.	10	12	12	14	14	16	16	18	20	20	22	22	26	26	30	30	30	30	34	34
Minimum Height of Stack. ft.	35	35	35	35	35	35	40	40	40	40	45	45	45	45	50	50	55	55	55	55
Diameter of Stack, Two Boilers. in.	16	18	18	20	20	22	22	26	28	28	30	32	34	34	36	36	36	38	40	42
Minimum Height of Stack, Two Boilers. ft.	40	40	40	40	40	40	40	45	45	45	45	45	50	55	55	65	65	65	65	65
Size of Steam Opening. in.	3	4	4	5	5	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8
Size of Return. in.	2	2½	2½	3	3	3	3	4	4	4	4	5	5	5	5	5	6	6	6	6
Size of Safety Valve. in.	1	1¼	1¼	1¼	1½	1½	2	2	2	2	2½	2½	2½	3	3	3½	3½	3½	4	4
C—Length of Grate. in.	26	26	32	38	32	38	44	44	50	44	50	56	56	62	62	68	62	68	68	74
D—Length of Ash-pit. in.	31	33	39	45	39	45	51	51	57	51	57	63	59	65	65	71	65	71	71	77
E—Width of Ash-pit. in.	19	24	24	24	30	30	30	36	36	42	42	42	49	49	54	54	60	60	66	66
F—Height of Ash-pit. in.	12	14	14	14	14	14	14	14	14	14	14	14	14	14	17	17	17	17	17	17
G—Height of Water-line. in.	45	52	52	52	55	55	55	58½	58½	61	61	61	66	66	75	75	80	80	85½	85½
H—Height of Boiler. in.	51	59	59	59	65	65	65	71	71	77	77	77	83	83	93	93	99	99	105	105
J—Location of Steam Supply. ft. in.	4-0	4-0	4-8	5-6	4-11	5-11	6-11	6-8	7-2	7-0	7-10	8-6	9-2	9-8	9-6	10-8	9-8	10-8	9-9	10-9
K—Location of Safety Valve. in.	12	12	15	16	15	18	18	13	13	16	18	18	21	30	26	30	26¾	30	20	34
L—Length of Foundation. in.	32	34	40	46	40	46	52	52	58	52	58	64	72	78	78	84	78	84	84	90
M—Width of Foundation. in.	27	34	34	34	40	40	40	46	46	52	52	52	75	75	80	80	86	86	92	92
N—Center to Center Bolts in Ash-pit Front. in.													54	54	60	60	66	66	72	72
O—Width of Breeching Connection. in.	10	8	8	8	10	10	10	10	10	10	10	10	10	10	12	12	12	12	13	13
P—Length of Breeching Connection. in.	10	16	16	16	24	24	24	30	30	36	36	36	46	46	50	50	54	54	68	68
Q—Height of Steam Supply. in.	53	61	61	61	67	67	67	73	73	79	79	79	85	85	95	95	101	101	107	107
R—Depth of Smoke Box. in.	12	16	16	16	16	16	16	16	16	16	16	16	16	16	18	18	18	18	18	18
S—Minimum Space Required at Rear. in.	24	18	18	18	21	21	21	24	24	27	27	27	30	30	33	33	36	36	39	39
T—Height of Return. in.	15½	18	18	19	19	19	19	19	19	19	19	20	20	20	23	23	23	23	23	23
W—Floor Line to Bottom of Cylinder. in.	27	29	29	29	29	29	29	29	29	29	29	29	29	29	33	33	33	33	33	33
†Req'd at Front to Draw Tubes. in.	25	19	20	20	20	26	31	26	32	32	38	44	49	67	55	73	61	73	49	62
†Req'd at Rear to Draw Tubes. in.	41	32	39	45	39	51	63	57	69	63	75	87	92	116	102	126	108	126	102	122
*Number of Common Brick.													460	490	710	740	740	760	790	820
Outside Surface to be Covered. sq. ft.	55	68	77	85	91	106	120	133	149	157	177	197	200	235	275	314	311	345	338	366

*Foundations not included. †If space is available at front, it is not necessary at rear, and vice-versa. Boilers No. 0K to No. 12K are furnished with cast iron base.
Full height back stand furnished with all boilers, no pier, see Letter W.



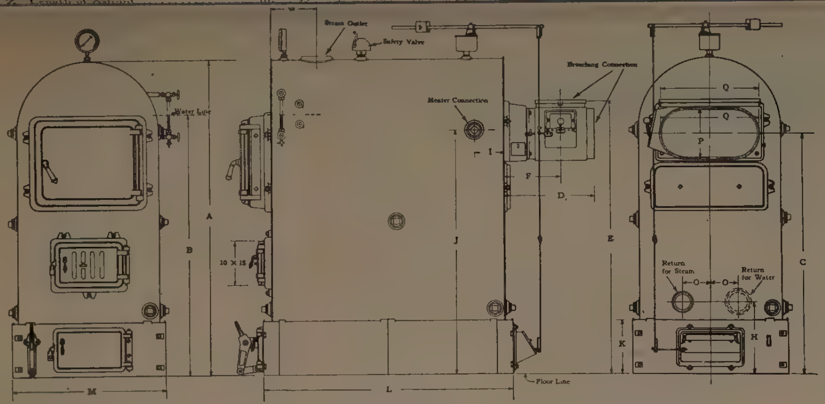




KEWANEE STEEL BOILERS TYPE C—ELECTRIC WELD

For Burning Coal

Number of Boiler		749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770
Capacity, Steam	sq. ft.	2300	2690	3250	3630	4060	4550	5250	5950	6470	7000	8280	9610	10850	12110	14300	16380	18660	20750	22520	25530	28780	33070
Heating Surface	sq. ft.	164	192	232	262	290	325	375	425	462	498	591	686	775	865	1025	1170	1333	1482	1608	1824	2056	2362
Area of Grate	sq. ft.	9.1	10.3	11.0	11.6	12.4	13.9	15.5	18.0	19.7	21.5	22.4	24.3	24.7	26.9	27.6	30.1	32.9	35.6	36.0	38.9	42.1	45.2
Diameter of Stack	in.	18	20	20	20	22	22	22	24	24	26	26	28	30	30	32	32	34	34	38	38	40	40
Minimum Height of Stack	ft.	45	50	50	55	55	55	60	60	60	65	65	65	70	70	70	70	80	90	90	90	100	100
Diameter of Stack, Two Boilers	in.	26	28	28	28	31	31	31	34	34	36	36	40	42	42	46	46	48	48	52	54	54	54
Minimum Height of Stack, Two Boilers	ft.	55	60	60	65	65	65	70	70	70	75	75	75	80	80	80	80	90	100	100	100	110	110
Size of Steam Opening	in.	6	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8	8	8	8	10	10	10
Size of Return Opening	in.	4	4	4	4	4	4	4	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6
Size of Safety Valve Opening	in.	2	2	2	2	2	2	2½	2½	3	3	3	3½	3½	3½	3½	4	4	2-2½	2-2½	2-3	2-3	2-3
A—Width of Boiler	in.	36	36	36	36	42	42	42	48	48	48	54	54	60	60	66	66	72	72	78	78	84	84
B—Length of Boiler	ft. in.	4-2	4-8	5-8	6-4	5-10½	6-6½	7-6	6-1	6-7	7-1	7-5½	8-7	8-0½	8-11	9-7	10-10	9-10½	10-11	10-10	12-2½	10-11	12-5
C—Overall Length of Boiler	ft. in.	5-10	6-4	7-4	8-0	7-10½	8-6½	9-6	8-3	8-9	9-3	9-8½	10-10	10-4½	11-3	11-11	13-2	12-8½	13-9	13-8	15-0½	13-9	15-3
D—Overall Height of Boiler	in.	77½	77½	77½	77½	83½	83½	83½	97	97	97	99	99	108½	108½	111½	111½	117½	117½	121½	121½	135	135
E—Height of Ash-pit Base	in.	14	14	14	14	14	14	14	14	14	14	14	14	17	17	17	17	17	17	17	17	21	21
F—Width of Grates and Ash-pit	in.	30	30	30	30	36	36	36	42	42	42	47½	47½	52½	52½	58½	58½	64	64	70	70	76	76
G—Length of Grates	in.	43	49	56	56	50	56	62	62	68	74	68	74	68	74	68	74	74	80	74	80	80	86
H—Height of Front Smokebox	in.	34	34	34	34	34	34	34	42	42	42	42	42	48	48	48	48	51	51	52	52	61	61
I—Top Front Smokebox to Top of Boiler	in.	10	10	10	10	13	13	13	16	16	16	16	16	16	16	18	18	17	17	19	19	21	21
J—Depth of Front Smokebox	in.	9	9	9	9	10	10	10	11	11	11	12	12	12	12	12	12	14	14	14	14	14	14
K—Depth of Rear Smokebox	in.	11	11	11	11	14	14	14	15	15	15	15	15	16	16	16	16	20	20	20	20	20	20
L—Height of Rear Smokebox	in.	26	26	26	26	29	29	29	35½	35½	35½	35	35	36	36	39	39	43	43	45½	45½	49½	49½
M—Diameter of Smoke Outlet	in.	22	22	22	22	24	24	24	26	26	26	28	28	32	32	34	34	36	36	40	40	42	42
N—Height Smoke Outlet above Floor	in.	64½	64½	64½	64½	69	69	69	79	79	79	81½	81½	90½	90½	93	93	96	96	99	99	110	110
O—Height of Water Column	in.	67	67	67	67	70	70	70	80	80	80	82	82	91	91	92½	92½	98	98	100	100	111½	111½
P—Height of Water Line	in.	69	69	69	69	72	72	72	82	82	82	85	85	94	94	95	95	101	101	103	103	114	114
Q—Height of Steam Supply	in.	79½	79½	79½	79½	85½	85½	85½	99	99	99	101	101	110½	110½	113½	113½	119½	119½	123½	123½	137	137
R—Height of Return	in.	18	18	18	18	18	18	18	19	19	19	19	19	22	22	22	22	22	22	22	22	26	26
S—Location of Steam Supply	in.	10½	14	14	16	14	16	18	16	18	21	18	21	18	21	18	21	21	21	21	21	21	24
T—Location of 1st Safety Valve	in.	8½	10	10	10	10	10	11	12	13	14	13	14	13	14	13	14	14	14	14	14	14	15
U—Location of 2nd Safety Valve	in.																		10	10	11	11	12
V—Location of Surface Blow-Off	in.	12	12	12	12	12	12	12	12	12	12	18	24	24	24	24	24	24	24	24	24	24	24
W—Width of Base	in.	38½	38½	38½	38½	44½	44½	44½	50½	50½	50½	56½	56½	63	63	69	69	75	75	81	81	87½	87½
X—Width of Foundation	in.	46	46	46	46	52	52	52	58	58	58	63½	63½	68½	68½	74½	74½	80	80	86	86	92	92
Y—Length of Foundation	in.	59	65	77	85	80	88	99	82	88	94	106	112	106	115	123	138	127	140	138	154	139	157



KEWANEE RESIDENCE TYPE R BOILERS

Nos. 740-770 For Burning Coal

Number of Boiler	740	741	742	743	745	746	747	748
Rated Capacity, Steam . . . . . . sq. ft.	370	510	690	920	1210	1560	1780	1960
Rated Capacity, Water . . . . . sq. ft.	590	820	1100	1470	1940	2500	2850	3140
Heating Surface . . . . sq. ft.	49	60	71	82	101	114	127	140
Grate Area . . . . sq. ft.	2.6	3.5	4 4	5.3	6 3	7.3	8.4	9 4
Width of Boiler . . . . in.	27	27	27	27	31	31	31	31
Length of Boiler . . . . in.	27½	33½	39½	45½	45½	51½	57½	63½
Size of Steam or Water Outlet . . . in.	3	3	4	4	5	6	6	6
Size of Steam Return Inlet . . . . . . in.	2½	2½	2½	2½	3	3	3	3
Size of Inlet added for Water . . . . in.	2½	2½	2½	2½	4	4	4	4
Size of Safety Valve Opening . . . . in.	1	1	1¼	1¼	1½	1½	1½	2
A—Overall Height, Floor to Top of Shell . . . . in.	66½	66½	66½	66½	70¼	70¼	70¼	70¼
B—Height of Water-line . . . . . . in.	56½	56½	56½	56½	58½	58½	58½	58½
Diameter of Chimney . . . . in.	12	12	12	12	16	16	16	16
Height of Chimney . . . . ft.	35	35	35	35	40	40	40	40
Diameter of Breeching . . . . in.	14	14	14	14	18	18	18	18
Size of Breeching Connection, P x Q . . . . in.	8½x17	8½x17	8½x17	8½x17	11x22	11x22	11x22	11x22
C—Height of End Breeching Connection Center in.	52	52	52	52	54	54	54	54
D—Back of Boiler to End Breeching Connection . . . . in.	17½	17½	17½	17½	20	20	20	20

Number of Boiler	740	741	742	743	745	746	747	748
E—Height of Breeching Connection . . . . in.	58½	58½	58½	58½	61½	61½	61½	61½
F—Back of Boiler to Top Breeching Connection Center . . in.	11¼	11¼	11¼	11¼	12½	12½	12½	12½
G—Steam Outlet Center to Boiler Front . . . . in.	11	11	11	11	12	12	12	12
H Height of Return Inlet Ctrs., in.	15¼	15¼	15¼	15¼	16	16	16	16
O—Return Inlet Offset from Boiler Center . . . . in.	5	5	5	5	6	6	6	6
Heater Connection Size . . . . in.	2	2	2	2	2	2	2	2
I—Heater Connection Center from Back of Boiler . . . . . . in.	6½	6½	6½	6½	6½	6½	6½	6½
J—Heater Connection, Height from Floor . . . . in.	52¼	52¼	52¼	52¼	54¼	54¼	54¼	54¼
K—Height of Base . . . . in.	12	12	12	12	12	12	12	12
L—Length of Base . . . . in.	31½	37½	43½	49½	49½	55½	61½	67½
M—Width of Base . . . . in.	30	30	30	30	34	34	34	34
Outside Surface to Cover, Unjacketed . . . . sq. ft.	38	44	49	54	60	66	71	77
Approximate Weight . . . . lbs.	1800	2000	2300	2500	2800	3050	3300	3550

Oil Burning Boiler Nos. 1740-1748—Capacity, Steam, 450 to 2380 sq. ft.; Water, 720 to 3810 sq. ft. For Anthracite, Nos. 2740-2770—Capacity, Steam, 430 to 1960 sq. ft.; Water, 690 to 3140 sq. ft

Leader Boiler and Heater Company

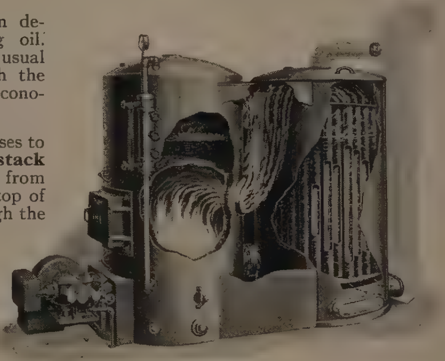
310 S. Michigan Avenue, Chicago, Ill.

"THE KOOLSTACK LINE"

Steel Heating Boilers for Oil, Gas, Coke.
Gas Fired Automatic Steam Boilers and Water Heaters.
Oil Fired Automatic Heating Units.
Economizers for Oil Burners, Storage Water Heaters.

Koolstack Boilers have been designed particularly for burning oil. They have far more than the usual amount of heating surface, with the result that they are extremely economical for oil burning.

In Place of allowing the hot gases to escape up the chimney, **Koolstack** construction passes these gases from the combustion chamber to the top of the rear section then down through the tubes and out at the bottom. This construction absorbs all the heat that is practical, allowing only such an amount to go up the chimney (usually around 300 deg. fahr.) as to insure proper draft conditions.



An Automatic Damper provides temporary draft acceleration at the initial firing period by automatically by-passing the products of combustion direct to the chimney. This damper closes when the stack temperature reaches 250 deg. fahr.

Koolstack Boilers are now available for use with any good forced draft oil burner in sizes shown in table below.

Complete Units. Koolstack Oil Fired Automatic Heat Machines consisting of oil burner and boiler built into one compact unit will be available January 1, 1930. Capacities of these units will range from 500 to 3,000 sq. ft. of steam. They are designed and built to give the highest efficiency obtainable in domestic heating equipment for burning oil. Write for Bulletin giving complete details.

Koolstack Boiler Ratings and Dimensions

Size	Steam		Water	Approx. Shipping Weight Lbs.	Grate Diam. In.	Width Overall In.	Height Overall In.	Length Overall In.	Size Smoke Outlet In.	Size Flow Opening In.	Size Return Opening In.
	Net Rating Sq. Ft.	Height of Water Level In.	Net Rating Sq. Ft.								
2848	800	37½	1280	2000	23½	36½	52¾	68½	10	3	3
2854	1000	42½	1600	2200	23½	36½	59½	68½	10	3½	3½
2860	1200	46½	1920	2400	23½	36½	65½	68½	10	4	4
3954	1600	42½	2880	3500	33½	46	61	90	12	4½	4½
3963	2100	48½	3520	3900	33½	46	70¼	90	12	4½	4½
3972	2600	56	4160	4300	33½	46	79¾	90	12	5	5

Koolstack Boilers are built in accordance with A. S. M. E. low pressure heating boiler code. All ratings are based on actual boiler capacity at outlet.

Molby Boiler Company *Incorporated*

Subsidiary of The Universal Pipe and Radiator Company

Molby Magazine-Feed Downdraft-Crossdraft Boilers

for burning No. 1 Buckwheat Anthracite

GRAYBAR BUILDING, LEXINGTON AVENUE AT 43rd STREET, NEW YORK

PHILADELPHIA BRANCH
2401 Chestnut Street

LANSDALE, PA. BRANCH
50 Central Avenue

CHICAGO BRANCH
332 S. Michigan Avenue

21 Sizes—for Homes, Apartment Houses and other large Buildings.

The Molby heating boiler pays for itself. It is self-feeding and gives a steady, even heat over long periods, burning No. 1 Buckwheat at half the cost of large sizes of anthracite. Also burns free-burning bituminous. Also coke. Magazines need coaling only once a day. Built throughout in accordance with codes of A. S. M. E. and A. S. H. & V. E.

Tested and Certified by Outside and Unbiased Engineers of National Reputation.

Tests have been made, not alone by our own engineers, but in the nationally-known Frost Research Laboratory, at Norristown, Pa.—and these laboratory tests are certified to by Mr. Robinson V. Frost, C. E., Member A. S. M. E. and A. S. H. & V. E.

For the benefit of engineers, architect and contractor we will gladly furnish charts in fullest detail, as submitted by the Frost Research Laboratory, showing grate areas, ratings, boiler performances and efficiencies. Ask nearest office for these charts.

SIZES, CAPACITIES, DIMENSIONS, ETC.

STEAM					STEAM AND WATER							WATER			
					Size—Inches										
Number	Water Line	Return	*Commercial Rating Steam	Advised Load Steam	Height	Width	Length	Smoke Pipe	Outlets	Chimney Flue	Approximate Shipping Weight	Number	Return	*Commercial Rating Water	Advised Load Water
S-1-4	43	2-3	375	275	54	41	35½	10	2-3	8x12	1890	W-1-4	2-3	600	450
S-1-5	43	2-3	507	375	54	41	42	10	2-3	8x12	2230	W-1-5	2-3	813	615
S-1-6	43	2-3	646	475	54	41	48½	10	2-3	8x12	2580	W-1-6	2-3	1035	780
S-1-7	43	2-3	779	575	54	41	55	10	2-3	12x12	2950	W-1-7	2-3	1247	945
S-1-8	43	2-3	908	675	54	41	61½	10	2-3	12x12	3300	W-1-8	2-3	1450	1110
S-2-5	48	2-4	1158	839	62½	61	44	14	2-3	12x12	3820	W-2-5	2-4	1852	1343
S-2-6	48	2-4	1466	1087	62½	61	50⅜	14	2-3	12x12	4290	W-2-6	2-4	2356	1739
S-2-7	48	2-4	1785	1334	62½	61	56¾	14	2-3	12x16	4690	W-2-7	2-4	2856	2135
S-2-8	48	2-4	2106	1585	62½	61	63⅛	14	3-3	12x16	5100	W-2-8	2-4	3370	2537
S-2-9	48	2-4	2431	1852	62½	61	69½	14	3-3	16x16	5510	W-2-9	2-4	3890	2964
S-2-10	48	2-4	2759	2138	62½	61	75⅞	14	3-3	16x16	5930	W-2-10	2-4	4414	3422
S-2-11	48	2-4	3093	2405	62½	61	82	14	4-3	16x16	6350	W-2-11	2-4	4934	3969
S-3-6	61	2-5	1817	1547	80	75½	59	14	2-4	16x16	7150	W-3-6	2-5	2907	2475
S-3-7	61	3-5	2470	1971	80	75½	67½	16	3-4	16x16	8310	W-3-7	3-5	3952	3155
S-3-8	61	3-5	2785	2434	80	75½	76	16	3-4	16x20	9500	W-3-8	3-5	4456	3895
S-3-9	61	3-5	3312	2942	80	75½	84½	18	3-4	16x20	10650	W-3-9	3-5	5300	4700
S-3-10	61	3-5	3898	3338	80	75½	93	18	4-4	20x20	11840	W-3-10	3-5	6236	5341
S-3-11	61	3-5	4351	3730	80	75½	101½	18	4-4	20x20	13000	W-3-11	3-5	6962	5969
S-3-12	61	3-5	4769	4081	80	75½	110	18	4-4	20x24	14150	W-3-12	3-5	7631	6530
S-3-13	61	3-5	5226	4454	80	75½	118½	18	4-4	20x24	15320	W-3-13	3-5	8361	7126
S-3-14	61	3-5	5660	4840	80	75½	127	18	4-4	20x24	16590	W-3-14	3-5	9057	7740

Note. In ordering 26-in. boilers state whether you wish same fitted up with right hand or left hand end to the chimney. length includes Smoke Box.

Equipment. Each steam boiler is equipped with a full set steam trimmings, a pressure regulator and a complete set of firing and cleaning tools. Instruction books for erecting and operating accompany each boiler. Each water boiler is equipped with a thermometer, a water temperature regulator and a complete set of firing and cleaning tools. Instruction books for erecting and operating accompany each boiler.

*When domestic hot water supply tank is to be heated by heating boiler add to actual load 2 sq. ft. for each gallon of tank capacity on a steam job, and 3 sq. ft. for each gallon on a hot water job.

Monitor Boiler Company

1505 Race Street **Philadelphia, Pa.**

Monco Fire Tube Steel Heating Boilers, Coil Steel Heating Boilers and Water Heaters for Coal and Oil Burning

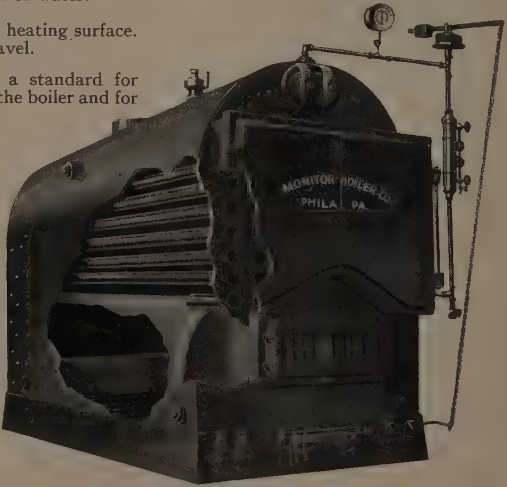
Monco Fire Tube Steel Heating Boilers are electrically welded and are designed according to the Code of the A. S. M. E. covering welded boilers and are constructed for a maximum working pressure of 15 lb. steam and 30 lb. water. All Boilers are constructed under the direct supervision of a Certified Insurance Inspector and are tested and stamped by this inspector before shipment.

The following are some of the outstanding features:

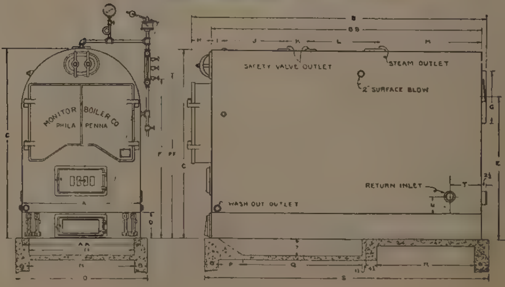
Arched self-cleaning crown sheet.
Large combustion chamber.
Unrestricted circulation of water.
Low water line.
Large amount of direct heating surface.
Long three-pass fire travel.

Ratings are based on a standard for steam of 2 lb. pressure at the boiler and for water on a mean temperature of 180 deg. as the water leaves the boiler. Any Monco Fire Tube Steel Heating Boiler will carry its full-rated load in direct radiation or equivalent, if sufficient radiation is installed to heat the building to 70 deg. fahr.

The standard equipment for coal burning boilers includes all castings as shown on boiler, heavy steel base and shaking grates. Standard steam trimmings include damper regulator, steam gauge with syphon, water column with gauge cocks and water glass, safety valve, tube, brush and firing tools. No trimmings furnished with hot water boilers.



Monco Fire Tube Steel Heating Boiler for Coal and Oil Burning



For Dimensions and Specifications see following page

Coal and Oil Burning Boilers

Monco Fire Tube

Steam Specifications

Catalog Number		Steam Rating		Shipping Weight Approx.		Grate Area, Sq. Ft.	Heating Surface	One Boiler Coal or Oil			Two Boilers Coal or Oil			Coal or Oil			
Coal	Oil	Coal	Oil	Coal	Oil			Diam. Smoke Breach'g	Diam Stack Inches	Min. Ht. Stack Feet	Diam. Smoke Breach'g	Diam. Stack Inches	Min. Ht. Stack Feet	Size Steam Outlet	Size Return	Safety Valve No.-Size	Covering Required Sq. Ft.
3011	3012	1200	1375	2700	2050	6.5	97	18	16	50	24	22	55	5	2-2½	1-1¼	50
3021	3022	1450	1670	3100	2400	7.0	123	18	16	55	24	22	60	5	2-2½	1-1¼	58
3031	3032	1700	1950	3500	2750	7.5	148	18	16	55	24	22	65	6	2-3	1-1¼	65
4011	4012	2000	2300	4300	3500	8.0	160	20	18	50	26	24	55	6	2-3	1-1½	85
4021	4022	2350	2700	5000	4050	9.5	193	20	18	55	26	24	60	6	2-3	1-1½	95
4031	4032	2700	3100	5600	4600	10.0	225	20	18	55	26	24	65	6	2-3	1-1½	104
4041	4042	3200	3675	6600	5400	12.0	264	22	20	55	28	26	60	6	2-3	1-2	105
4051	4052	3800	4350	7500	6100	14.0	310	22	20	60	28	26	65	6	2-3	1-2	112
4061	4062	4400	5000	8200	6600	16.0	356	22	20	65	28	26	70	6	2-3	1-2½	120
4711	4712	5000	5700	8450	6750	17.0	383	24	22	60	34	32	65	8	2-4	1-2½	125
4721	4722	5600	6300	9200	7350	18.5	439	24	22	65	34	32	70	8	2-4	1-2½	130
4731	4732	6200	7100	9920	7920	20.0	496	24	22	70	34	32	75	8	2-4	1-3	135
5511	5512	7850	9000	12600	10350	22.5	604	26	24	65	36	34	70	8	2-4	1-3	159
5521	5522	8700	9700	13500	11050	24.5	673	26	24	70	36	34	75	8	2-4	1-3	174
5531	5532	9600	11000	14200	11550	26.5	742	26	24	75	36	34	80	8	2-4	1-3½	190
6511	6512	11000	12750	16600	13800	28.0	829	28	26	70	38	36	75	10	2-5	1-3½	192
6521	6522	12200	14000	17675	14675	30.0	925	28	26	75	38	36	80	10	2-5	2-2½	210
6531	6532	13500	15500	18400	15250	31.5	1020	28	26	80	38	36	85	10	2-5	2-3	228
7411	7412	18000	20700	24000	20350	36.5	1332	30	28	75	42	40	80	10	2-5	2-3	235
7421	7422	19800	22700	25000	21050	39.5	1471	30	28	80	42	40	85	10	2-5	2-3½	250
7431	7432	21700	25000	25400	21300	41.0	1610	30	28	85	42	40	90	10	2-5	2-3½	265

Height Water Line—see FF in table below. Height Boiler—see C in table below. Length Boiler —see BB in table below. Width Boiler—see A in table below. To figure ratings of hot water boilers add 60 per cent to steam rating.

Measurements of Monco Fire Tube Boilers

Number of Boiler	Width of Boiler	Width of Base	Length of Boiler Overall	Length of Boiler	Height of Boiler	Height of Base	Floor to Center of Smoke Connection	Floor to Bottom of Water Gauge	Height of Water Line	Diameter of Smoke Connection	Depth of Front Smoke Hood	Location of Water Column	Location Safety Valve	Distance Between Safety Valves	Distance from Safety Valve to Steam Outlet	Location Steam Outlet	Width of Ashpit	Width of Foundation	Foundation Dimensions	Foundation Dimensions	Foundation Dimensions	Length of Foundation	Location of Returns	Location of Returns
	A	AA	B	BB	C	D	E	F	FF	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
301*	30	30	62	51½	62½	12	49¼	52	54½	18	8	6	7½	....	12	26	22	38	8	32		59½	11⅜	9
302*	30	30	74	63½	62½	12	49¼	52	54½	18	8	6	13½	....	12	32	22	38	8	32	9½	71½	11⅜	9
303*	30	30	86	75½	62½	12	49¼	52	54½	18	8	6	13½	....	18	38	22	38	8	32	21½	83½	11⅜	9
401*	40	40	76½	64	69	12	53½	56½	59	20	10	6	12	....	12	34	32	48	15	17	18	72	11⅜	9
402*	40	40	88½	76	69	12	53½	56½	59	20	10	6	14	....	16	40	32	48	15	25	22	84	11⅜	9
403*	40	40	100½	88	69	12	53½	56½	59	20	10	6	16	....	20	46	32	48	15	33	26	96	11⅜	9
404*	40	40	91½	78	80	12	62	66½	69	22	11	6	12	....	18	42	32	48	15	41	8	86	13½	9
405*	40	40	103½	90	80	12	62	66½	69	22	11	6	16	....	20	48	32	48	15	49	12	98	13½	9
406*	40	40	115½	102	80	12	62	66½	69	22	11	6	24	....	20	52	32	48	15	57	16	110	13½	9
471*	47	47	103½	90	84	12	63	68½	71	24	11	6	16	....	20	48	39	55	18	38	20	98	12¾	9¼
472*	47	47	115½	102	84	12	63	68½	71	24	11	6	24	....	20	52	39	55	18	46	24	110	12¾	9¼
473*	47	47	127½	114	84	12	63	68½	71	24	11	6	28	....	20	60	39	55	18	54	28	122	12¾	9¼
551*	55	55	127¾	114	89	12	68	72½	75	26	11¼	6	30	....	18	60	47	63	18	46	36	122	12¾	8¾
552*	55	55	139¾	126	89	12	68	72½	75	26	11¼	6	32	....	22	66	47	63	18	54	40	134	12¾	8¾
553*	55	55	151¾	138	89	12	68	72½	75	26	11¼	6	38	....	22	72	47	63	18	62	44	146	12¾	8¾
651*	64½	64½	132¼	117½	104	15	81½	86½	89	28	12¼	6	33½		15	63	56½	72½	18	54	31½	125½	14¾	11⅛
652*	64½	64½	144¼	129½	104	15	81½	86½	89	28	12¼	6	36½	12	18	57	56½	72½	18	62	35½	137½	14¾	11⅛
653*	64½	64½	156¼	141½	104	15	81½	86½	89	28	12¼	6	39½	12	27	57	56½	72½	18	62	47½	149½	14¾	11⅛
741*	73½	73½	144¼	129½	122	15	89⅝	99½	102	30	12¼	6	36½	12	18	57	65½	81½	18	62	35½	137½	14¾	10¾
742*	73½	73½	156¼	141½	122	15	89⅝	99½	102	30	12¼	6	39½	12	27	57	65½	81½	18	70	39½	149½	14¾	10¾
743*	73½	73½	168¼	153½	122	15	89⅝	99½	102	30	12¼	6	42½	15	30	60	65½	81½	18	70	51½	161½	14¾	10¾

*Numbers of all Monco Fire Tube Boilers, Coal and Oil Burning, begin with these three numerals.

NATIONAL RADIATOR CORPORATION

General Offices: **Johnstown, Pa.**

Branch Offices and Warehouses

BALTIMORE........2622 Matthews Street
BOSTON........93-97 Oliver Street
BUFFALO........259 Delaware Avenue
CHICAGO........2445 North Keeler Avenue
CINCINNATI........3530 Spring Grove Avenue
CLEVELAND........935 East Sixty-third Street
DETROIT........Suite 903, Fisher Building
INDIANAPOLIS........431 W. Georgia Street
JOHNSTOWN........221 Central Avenue
MILWAUKEE........2003 St. Paul Avenue
NEW YORK........55 West Forty-second Street
OMAHA........1101 Jackson Street
PHILADELPHIA........121 North Broad Street
PITTSBURGH........1509 Arrott Building
RICHMOND........3032 Norfolk Street
ST. LOUIS........1042 Central Industrial Street
WASHINGTON, D. C........2205 Fifth Street, N.E.

Manufacturers of

National Aero Radiators and Panel Radiators, National Bonded Round Boilers, Jacketed Boilers, Super-Smokeless Boilers, Imperial Sectional Boilers, Low Water Line Boilers, Contento Boilers and Gas Boilers

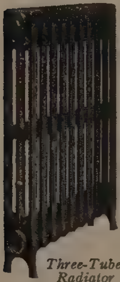
Seven-Tube Window Radiator

National Aero Radiation

Style—Steam or Water	Distance from Floor to Center of Top Tapping	Height in In.	Square Feet per Section
3 Tube—Width of Section 5⅛"	33 13/16	36	3½
	27 27/32	30	3
	23 13/16	26	2⅛
	20 53/64	23	2
	17 27/32	20	1¾
4 Tube—Width of Section 6 13/16"	33 13/16	36	4¼
	27 27/32	30	3½
	23 13/16	26	2¾
	20 53/64	23	2½
	17 27/32	20	2¼
5 Tube—Width of Section 8 13/32"	33 13/16	36	5
	27 27/32	30	4⅓
	23 13/16	26	3½
	20 53/64	23	3
	17 27/32	20	2⅔
6 Tube—Width of Section 9"	35⅞	38	6
	29⅞	32	5
	23⅞	26	4
	20⅝	23	3½
	17⅞	20	3
7 Tube—Width of Section 12"	33 13/16	36	6¾
	27 27/32	30	5½
	23 13/16	26	4¾
	17 27/32	20	3⅔
	14 11/32	16½	3
	11⅜	13½	2½

Floor to center bottom tapping—4½ in., excepting 13½ in. and 16½ in. 7 Tube which is 3 in.

Five-Tube Radiator



Three-Tube Radiator

Legless Radiator

National Aero Wall Radiation

Sections Number	Height Inches	Length or Width—Inches	Center to Center Tappings—Inches	Sq. Ft. Per Section
7A	13 5/16	21⅞	9 15/16	7
9A	13 5/16	29 1/16	9 15/16	9
7B	21⅞	13 5/16	18 25/64	7
9B	29 1/16	13 5/16	25 19/32	9

Thickness of sections—2⅞ in. 7A and 9A—horizontal sections. 7B and 9B—vertical sections.

Wall Radiator

National Panel Radiators are described and illustrated on page 774

National Bonded Jacketed Square Boilers

Jacketed attractively for eye-appeal, the National Jacketed Boiler's chief claim to esteem is in its demonstrated quality. Quality built-in, hidden away, but expressing itself in outstanding efficiency, and upstanding service. Large grates, deep fire box, properly proportioned combustion chamber, long fire travel, unite to make this boiler easily fired, easy on fuel. Engineering design scientifically coordinates every part.

Steam Boiler No.	Steam		Water Boiler No.	Water		Grate Area Sq. Ft.	Base Dimensions In.	Number Outlets, Sizes In.	Chimney	
	* Available Output Rating Sq. Ft.	Bonded Direct C. I. Radiation Sq. Ft.		* Available Output Rating Sq. Ft.	Bonded Direct C. I. Radiation Sq. Ft.				Area In.	Height Ft.
2 Series—Height of Water Line, 46". Height Flow Outlet, 56". Width of Base, 25⅜". Size Smoke Pipe, 9".										
2-S-4	400	200	2-W-4	675	330	1.5	25⅜x17¼	2-2½	8x8	30
2-S-5	575	300	2-W-5	950	495	2.0	25⅜x21½	2-2½	8x8	30
2-S-6	750	400	2-W-6	1,250	660	2.5	25⅜x25¾	2-2½	8x8	30
2-S-7	925	500	2-W-7	1,550	825	3.0	25⅜x30	2-2½	8x12	35
2-S-8	1,100	600	2-W-8	1,850	990	3.5	25⅜x34¼	3-2½	8x12	35
2-S-9	1,275	675	2-W-9	2,150	1,110	4.0	25⅜x38½	3-2½	8x12	35
3 Series—Height of Water Line, 47". Height Flow Outlet, 54". Width of Base, 30¼". Size Smoke Pipe, 10".										
3-S-5	900	450	3-W-5	1,500	740	3.12	30¼x27¾	2-3	8x12	35
3-S-6	1,100	550	3-W-6	1,850	905	3.91	30¼x33⅝	2-3	8x12	35
3-S-7	1,300	650	3-W-7	2,200	1,070	4.70	30¼x39½	3-3	8x12	35
3-S-8	1,500	750	3-W-8	2,550	1,235	5.49	30¼x45⅜	3-3	8x12	40
4 Series—Height of Water Line, 49". Height Flow Outlet, 57¼". Width of Base, 38⅝". Size Smoke Pipe, 12".										
4-S-5	1,475	600	4-W-5	2,400	990	4.78	38⅝x32 11/16	2-4	12x12	30
4-S-6	1,800	800	4-W-6	2,900	1,320	5.95	38⅝x39 9/16	2-4	12x12	35
4-S-7	2,125	1,000	4-W-7	3,500	1,650	7.12	38⅝x46 7/16	3-4	12x12	35
4-S-8	2,450	1,200	4-W-8	4,000	1,980	8.29	38⅝x53 5/16	3-4	12x12	40
4-S-9	2,775	1,400	4-W-9	4,500	2,310	9.46	38⅝x60 3/16	3-4	12x16	45

*Listed as a means of comparison with similarly rated boilers.

National Bonded Novus Sectional Boilers

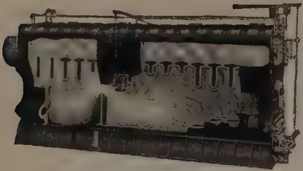
Standard for almost twenty years, the Novus Boiler has been consistently renowned for honesty of rating, and reliability of performance. This comprehensive National Novus Line provides a time-tried unit for steam, hot water, or vapor systems in a variety of applications ranging from the smallest home to the largest building.

Steam Boiler No.	Steam		Water Boiler No.	Water		†Grate Area Sq. Ft.	Length Sections Only In.	Length Sections and Smoke Box In.	Number Outlets, Sizes In.	Chimney		‡Boiler Covering Sq. Ft. Surface
	* Available Output Rating Sq. Ft.	Bonded Direct C. I. Radiation Sq. Ft.		* Available Output Rating Sq. Ft.	Bonded Direct C. I. Radiation Sq. Ft.					Area In.	Height Ft.	
20 Series—Height of Water Line, 47". Height Flow Outlet, 54". Width of Section, 28". Size Smoke Pipe, 10".												
20- 5-S	900	450	20-5-W	1,500	740	3.12	27 5/16	40 13/16	2-3	8x12	35	28
20- 6-S	1,100	550	20-6-W	1,850	905	3.91	33 3/16	46 11/16	2-3	8x12	35	32
20- 7-S	1,300	650	20-7-W	2,200	1,070	4 70	39 1/16	52 9/16	3-3	8x12	35	36
20- 8-S	1,500	750	20-8-W	2,550	1,235	5.49	44 15/16	58 7/16	3-3	8x12	40	40
25 Series—Height of Water Line, 49". Height Flow Outlet, 57¼". Width of Section, 36½". Size Smoke Pipe, 12".												
25- 5-S	1,475	600	25-5-W	2,400	990	4 78	32 7/16	49 3/16	2-4	12x12	30	39
25- 6-S	1,800	800	25-6-W	2,900	1,320	5.95	39 5/16	56 1/16	2-4	12x12	35	45
25- 7-S	2,125	1,000	25-7-W	3,500	1,650	7.12	46 3/16	62 13/16	3-4	12x12	35	51
25- 8-S	2,450	1,200	25-8-W	4,000	1,980	8.29	53 1/16	69 15/16	3-4	12x12	40	57
25- 9-S	2,775	1,400	25-9-W	4,500	2,310	9.46	59 15/16	76 11/16	3-4	12x16	45	63
48 Series—Height of Water Line, 68". Height Flow Outlet, 80". Width of Section, 67". Size Smoke Pipe, 20".												
48- 6-S	7,500	3,500	48-6-W	12,100	5,750	17.75	59⅛	78⅜	2-6	20x20	60	110
48- 7-S	9,000	4,200	48-7-W	14,500	6,900	21.30	69⅛	88⅞	2-6	20x24	65	125
48- 8-S	10,500	4,900	48-8-W	17,000	8,050	24.85	80⅛	99⅜	3-6	24x24	70	139
48- 9-S	12,000	5,600	48-9-W	19,300	9,200	28.40	90⅝	109⅞	3-6	24x28	75	153
48-10-S	13,500	6,300	48-10-W	21,700	10,350	31 95	101⅛	120⅜	3-6	24x28	75	167
48-11-S	15,000	7,000	48-11-W	24,100	11,500	35.50	111⅝	130⅞	4-6	28x28	80	182

*Listed as a means of comparison with similarly rated boilers.

‡Square feet of exterior boiler surface. Approximate number of pounds of covering per boiler section: 20 series, 50 lb.; 25 series, 60 lb.; 48 series, 67 lb.

†Grate Area measured at Grate Level.



National Bonded Super-Smokeless Boiler

Distinguished for its swirling scarlet flame, this boiler is scientifically designed for the efficient and smokeless combustion of all grades of fuel. The green coal cokes on the front of the grate—the distilled gases pass back to unite with preheated, proportioned, finely divided, and fully distributed secondary air, and are completely consumed.

Steam Boiler No.	Steam		Water			Grate Area Sq. Ft.	Length Sections Only In.	Length Sections and Smoke Box In.	Number Outlets, Sizes In.	Chimney		‡Boiler Covering Sq. Ft. Surface
	Available Output Rating Sq. Ft.	Bonded Direct C. I. Radiation Sq. Ft.	Water Boiler No.	Available Output Rating Sq. Ft.	Bonded Direct C. I. Radiation Sq. Ft.					Area In.	Height Ft.	
24 Series—Height of Water Line, 45½". Height Flow Outlet, 54". Width of Section, 35½". Size Smoke Pipe, 14".												
S-245	1,600	700	W-245	2,600	1,155	5.00	37¼	46¾	1–4	12x12	40	34
S-246	2,000	925	W-246	3,250	1,525	6.25	45½	55	2–4	13x13	40	42
S-247	2,400	1,150	W-247	3,900	1,900	7.50	53¾	63¼	2–4	13x13	45	50
S-248	2,800	1,375	W-248	4,550	2,270	8.75	62	71½	2–4	14x14	50	58
S-249	3,200	1,600	W-249	5,200	2,640	10.00	70¼	79¾	3–4	14x14	55	64
33 Series—Height of Water Line, 53". Height Flow, 64½". Width of Section, 47". Size Smoke Pipe, 16".												
S-335	2,900	1,300	W-335	4,650	2,150	7.32	37¼	47¾	1–5	14x14	40	42
S-336	3,600	1,650	W-336	5,800	2,725	9.10	45½	56	2–5	15x15	40	51
S-337	4,300	2,000	W-337	6,950	3,300	10.87	53¾	64¼	2–5	16x16	40	60
S-338	5,000	2,350	W-338	8,100	3,875	12.65	62	72½	2–5	16x16	50	69
S-339	5,700	2,700	W-339	9,250	4,450	14.42	70¼	80¾	3–5	18x18	50	78
S-3310	6,400	3,050	W-3310	10,400	5,025	16.20	78½	89	3–5	18x18	55	87
40 Series—Height of Water Line, 57". Height Flow Outlet, 69". Width of Section, 57½". Size Smoke Pipe, 20".												
S-406	5,200	2,300	W-406	8,300	3,795	12.03	45½	55¾	2–5	16x16	50	50
S-407	6,200	2,800	W-407	9,900	4,620	14.38	53¾	65	3–5	18x18	50	66
S-408	7,200	3,300	W-408	11,500	5,445	16.73	62	72¼	3–5	18x18	55	76
S-409	8,200	3,800	W-409	13,100	6,270	19.08	70¼	80½	3–5	20x20	55	86
S-4010	9,200	4,300	W-4010	14,700	7,095	21.43	78½	88¾	3–5	20x20	60	96
S-4011	10,200	4,800	W-4011	16,300	7,920	23.77	86¾	97	3–5	21x21	60	106
S-4012	11,200	5,300	W-4012	17,900	8,745	21.43	95	105¼	4–5	22x22	65	116
S-4013	12,200	5,800	W-4013	19,500	9,570	21.43	103¼	113½	4–5	22x22	70	126
S-4014	13,000	6,300	W-4014	20,800	10,395	23.77	111½	121¾	4–5	23x23	75	136
S-4015	13,800	6,800	W-4015	22,100	11,220	23.77	119¾	130	4–5	23x23	75	146
S-4016	14,600	7,300	W-4016	23,400	12,045	23.77	128	138¼	4–5	24x24	80	156
S-4017	15,400	7,800	W-4017	24,700	12,870	23.77	136¼	146½	4–5	24x24	80	166
S-4018	16,200	8,300	W-4018	26,000	13,695	23.77	144½	154¾	4–5	25x25	80	176
S-4019†	17,000	8,700	W-4019†	27,300	14,355	23.77	152¾	163	5–5	25x25	85	186
S-4020†	17,600	9,100	W-4020†	28,200	15,015	23.77	161	171¼	5–5	25x25	90	196
S-4021†	18,200	9,500	W-4021†	29,200	15,675	23.77	169¼	179½	5–5	25x25	100	206
S-4022†	18,800	9,900	W-4022†	30,200	16,335	23.77	177½	187¾	6–5	26x26	100	216
S-4023†	19,400	10,300	W-4023†	31,200	16,995	23.77	185¾	196	6–5	27x27	100	226
S-4024†	20,000	10,700	W-4024†	32,200	17,655	23.77	194	204¼	6–5	27x27	100	236

National Bonded Imperial Sectional Boilers

Steam Boiler No.	Steam		Water			Grate Area Sq. Ft.	Length Sections Only In.	Length Sections and Smoke Box In.	Number Outlets, Sizes In.	Chimney		‡Boiler Covering Sq. Ft. Surface
	Available Output Rating Sq. Ft.	Bonded Direct C. I. Radiation Sq. Ft.	Water Boiler No.	Available Output Rating Sq. Ft.	Bonded Direct C. I. Radiation Sq. Ft.					Area In.	Height Ft.	
32 Series—Height of Water Line, 53". Height of Top Outlet, 64½". Width of Section, 47". Size Smoke Pipe, 16".												
S-532	2,900	1,200	W-532	4,650	1,980	7.32	37¼	47¾	2–5	14x14	40	42
S-632	3,600	1,500	W-632	5,800	2,475	9.10	45½	56	2–5	15x15	40	51
S-732	4,300	1,800	W-732	6,950	2,970	10.87	53¾	64¼	2–5	16x16	40	60
S-832	5,000	2,100	W-832	8,100	3,465	12.65	62	72½	2–5	16x16	50	69
S-932	5,700	2,400	W-932	9,250	3,960	14.42	70¼	80¾	3–5	18x18	50	78
42 Series—Height of Water Line, 57". Height of Top Outlet, 69". Width of Section, 57½". Size Smoke Pipe, 20".												
S-642	5,200	2,200	W-642	8,300	3,625	12.03	45½	55¾	2–5	16x16	50	56
S-742	6,200	2,700	W-742	9,900	4,450	14.38	53¾	65	2–5	18x18	50	66
S-842	7,200	3,200	W-842	11,500	5,275	16.73	62	72¼	3–5	18x18	55	76
S-942	8,200	3,700	W-942	13,100	6,100	19.08	70¼	80½	3–5	20x20	55	86
S-1042	9,200	4,200	W-1042	14,700	6,925	21.43	78½	88¾	3–5	20x20	60	96
S-1142	10,200	4,700	W-1142	16,300	7,750	23.77	86¾	97	3–5	21x21	60	106
S-1242	11,200	5,100	W-1242	17,900	8,400	26.12**	95	105¼	4–5	22x22	65	116
S-1342	12,200	5,500	W-1342	19,500	9,050	28.47*	103¼	113½	4–5	22x22	70	126
S-1442	13,000	5,900	W-1442	20,800	9,700	30.82*	111½	121¾	4–5	23x23	75	136
S-1542	13,800	6,300	W-1542	22,100	10,350	33.17*	119¾	130	4–5	23x23	75	146
S-1642	14,600	6,700	W-1642	23,400	11,000	35.52*	128	138¼	4–5	24x24	80	156

*Maximum grate area which can be furnished. Unless otherwise ordered these sizes are shipped with 10 grate bars having a grate area of 23.77 sq. ft. **Shipped with 9 grate bars having area of 21.43 sq. ft.

‡Square feet of exterior boiler surface. Approximate number of pounds of covering per boiler section, 24 series, 50 lb.; 32 and 33 series, 60 lb.; 40 and 42 series, 67 lb.

†Recommended only for oil burning on ordinary stack.

Newport Boiler Company

General Offices: 529 S. Franklin St., Chicago

MAGAZINE FEED

OIL BURNING

Distributors—All Principal Cities United States and Canada

This boiler cuts fuel bills from 30 to 50 per cent burning No. 1 Buckwheat coal

"Newport"—alone, provides these Heater essentials:

Convenience Coaling only necessary from once a day to once a week, depending upon the weather. It is therefore the Home Owner's choice.

Economy "Newport" combustion is complete, conforming to all the laws of science. Saves from $5 to $7 per ton, burning No. 1 Buckwheat coal.

Uniform Heat is provided by the never varying thickness of the fuel bed, that supplies heat for every nook and corner, automatically controlled.

Adaptability the patented, adjustable throat, which is water cooled, insures maximum efficiencies, burning all sizes and kinds of coal, coke or oil.

NEWPORT COAL BURNING BOILERS

Boiler Number Steam	Rating Square Feet	*Maximum Direct Radiation Load	Boiler Number Water	Rating Square Feet	*Maximum Direct Radiation Load	Length Overall	Width Overall	Chimney Flue Size Inches	Chimney Flue Height Feet
STEAM			WATER						
S-4	594	340	W-4	1000	572	30¼"	32"	8 x 12	35
S-5	750	430	W-5	1250	714	36½"	32"	8 x 12	35
S-6	907	518	W-6	1500	857	42¾"	32"	8 x 12	40
S-7	1063	607	W-7	1750	1000	49"	32"	12 x 12	40
S-8	1219	696	W-8	2000	1143	55¼"	32"	12 x 12	45
S-55	1375	786	W-55	2282	1304	44"	56"	12 x 12	40
S-66	1688	965	W-66	2782	1590	50¼"	56"	12 x 16	45
S-77	2000	1143	W-77	3313	1893	56½"	56"	12 x 16	45
S-88	2313	1322	W-88	3813	2179	62¾"	56"	16 x 16	50
S-99	2625	1500	W-99	4313	2464	69"	56"	16 x 16	50
S-1010	2938	1679	W-1010	4813	2749	75¼"	56"	18 x 18	50
S-1111	3250	1858	W-1111	5313	3035	81½"	56"	18 x 18	55

NEWPORT OIL BURNING BOILERS

O-S-4	594	340	O-W-4	1000	572	30¼"	32"	8 x 12	35
O-S-5	750	430	O-W-5	1250	714	36½"	32"	8 x 12	35
O-S-6	907	518	O-W-6	1500	857	42¾"	32"	8 x 12	40
O-S-7	1063	607	O-W-7	1750	1000	49"	32"	12 x 12	40
O-S-8	1219	696	O-W-8	2000	1143	55¼"	32"	12 x 12	45
O-S-55	1375	786	O-W-55	2282	1304	44"	56"	12 x 12	40
O-S-66	1688	965	O-W-66	2782	1590	50¼"	56"	12 x 16	45
O-S-77	2000	1143	O-W-77	3313	1893	56½"	56"	12 x 16	45
O-S-88	2313	1322	O-W-88	3813	2179	62¾"	56"	16 x 16	50
O-S-99	2625	1500	O-W-99	4313	2464	69"	56"	16 x 16	50
O-S-1010	2938	1679	O-W-1010	4813	2749	75¼"	56"	18 x 18	50
O-S-1111	3250	1858	O-W-1111	5313	3035	81½"	56"	18 x 18	55

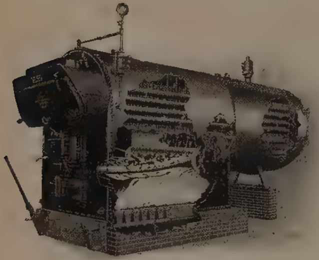
*The "Maximum Direct Radiation Load" is the maximum actual amount of square feet of cast iron column radiation or its equivalent that we recommend be attached to boiler. This amount provides a safety factor of 75 per cent, being ample for average conditions, to take care of the load imposed by mains, risers, etc., but does not provide an allowance for the heating of water for domestic use, or any extra load where attached radiation will condense more than 0.25 (¼) lb. of steam, per square foot per hour.

The water line on all Steam Boilers is 40½ in. Height overall Coal Boilers 62 in. Oil Boilers 48¾ in.

OIL CITY BOILER WORKS Oil City~Pa.

Branch Offices

ALBANY, N. Y.
ATLANTA, GA.
BALTIMORE, MD.
BOSTON, MASS.
CHARLOTTE, N. C.
CHICAGO, ILL.
CLEVELAND, OHIO
CINCINNATI, OHIO
DETROIT, MICH.
FORT WORTH, TEXAS
INDIANAPOLIS, IND.
KNOXVILLE, TENN.
LOS ANGELES, CALIF.
MEMPHIS, TENN.
NEW YORK, N. Y.
PITTSBURGH, PA.
PHILADELPHIA, PA.
RICHMOND, VA.
ROCHESTER, N. Y.
SAN ANTONIO, TEXAS
SHREVEPORT, LA.
TULSA, OKLA.
TORONTO, CANADA



"Oil City" Smokeless Boiler

"OIL CITY" low pressure boilers both riveted and welded types are offered to the trade as the last word in "Heating Economy and Reliability;" comprising in one completely assembled unit all the necessary elements of a modern plant for steam or hot water heating. These boilers are especially adapted for Schools, Office Buildings, Hotels, Churches, Hospitals, Theatres and Club Houses or for any purpose where the service of a universally recognized fire box boiler of high merit is desired.

"OIL CITY" boilers are designed and constructed to meet all the requirements of modern engineering practices as formulated by the American Society of Mechanical Engineers, the boiler laws of the various states and cities and are backed by over 50 years of successful practical experience.

Description—"OIL CITY" boilers are built in smokeless and straight draft types both riveted and welded for portable and brick settings. Riveted boilers can be furnished with cast iron base ready for setting on foundations. Welded boilers are equipped with an all steel base ready to receive the boiler thereby eliminating all brickwork.

These boilers are constructed with large fire boxes thereby insuring ample combustion space in which the heat-giving gases and air can thoroughly mix and burn before entering the tubes.

Type "X" Welded Boiler

The arrangement of tubes in relation to the shell allows free circulation of water at all times, and together with a liberal steam space insures an adequate constant supply of dry steam and a steady water level.

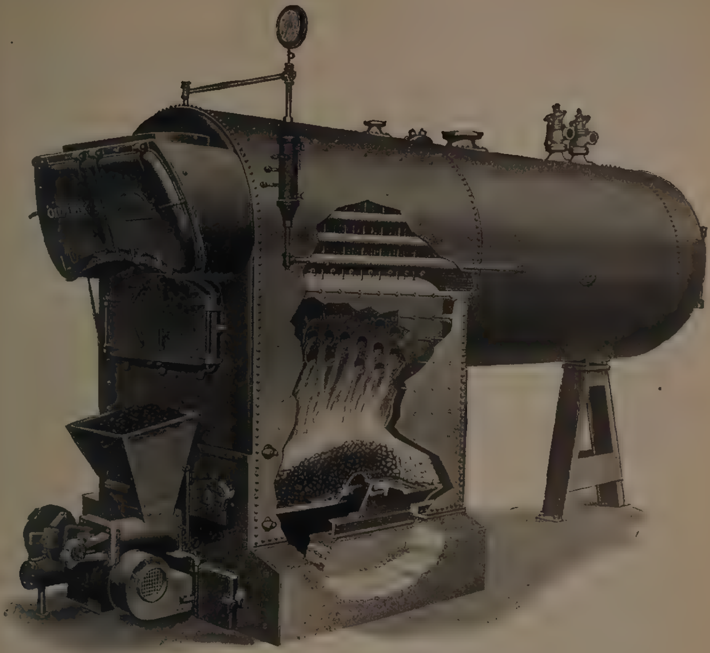
Ratings—Ratings are very conservative, only such parts of the boiler coming in contact with the passage of hot gases on one side and having water on the other being considered as effective heating surface.

Equipment—Equipment with all boilers includes, in addition to a complete set of sectional shaking grates suitable to the type of coal used, all necessary castings, safety valves, steam gauge, water column; baffle arch or tile, etc., as may be required for a complete installation.

Oil-Fired—Where oil is to be used exclusively we strongly recommend our Series 1900 Portable Return Tubular Fire Box Oil Burning Boiler where a riveted boiler is desired and when a welded boiler is to be employed we recommend either our "Type" "X" or "Type" "W" three pass boiler all of which have an exceptionally large fire box which is essential for the proper combustion of oil fuel.

Every "OIL CITY" boiler bears the official stamp of the A. S. M. E. Boiler Code as well as that of the boiler insurance inspector who supervises the construction of the boiler in our shops.

At a small increase in cost "OIL CITY" boilers are furnished, braced and stayed for a safe working pressure of 100 or 125 lb. Complete specifications and measurements can be obtained by writing for circulars.



"Oil City" Stoker-Unit Fire Box Boiler

A self-contained unit possible of high efficiency and high ratings which can be fired smokelessly using low grades of bituminous coal. Automatic regulation may be applied eliminating entirely the human element in firing. It has the approval of Smoke Abatement Bureaus of several of our large cities.

One of the special features of this boiler is the manner in which it has been designed to accommodate a stoker, keeping it surrounded by the water walls of the firebox with the water leg ring well below the combustion zone. The cut-out front used in this construction eliminates the necessity of using a special high refractory brick wall around the setting and its subsequent maintenance which is necessary to protect the water leg ring from the direct heat of combustion as is required with the ordinary type of fire-box boiler. In addition the elimination of this refractory wall leaves an exceptionally large free grate area. The length and width of the furnace are so proportioned to afford ample grate surface and together with the exceptionally high crown sheet make possible constant operation at high overloads. Actual tests have shown that 150 per cent ratings and higher can easily be maintained without seriously effecting the efficiency.

The water space surrounding the fire box has been considerably increased so as to bring to this high temperature zone a relatively larger volume of water than is found in boilers of this type. This factor not only improves the water circulation around this area of high heat concentration but also permits of a more quiet liberation of steam which in turn results in a steadier water line especially under forced conditions.

The furnace doors, rear doors and smoke-box doors are of a special grooved construction, machined and asbestos packed to prevent leakage or air infiltration at the joints.

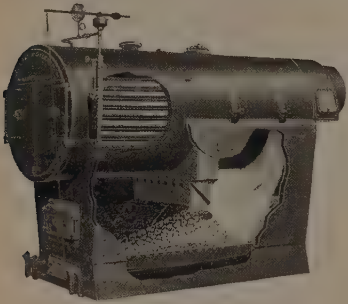
The "STOKER-UNIT" Boiler is made in sizes ranging from 75 to 300 h.p. and for working pressures from 15 to 125 lb., all in strict compliance with the A. S. M. E. Boiler Code. The low pressure or 15 lb. boilers are built either riveted or welded as specified.

Pacific Steel Boiler Corporation

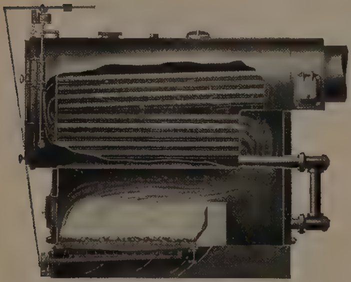
Manufacturers of

Pacific Steel Heating Boilers, Pacific Circulating Tanks

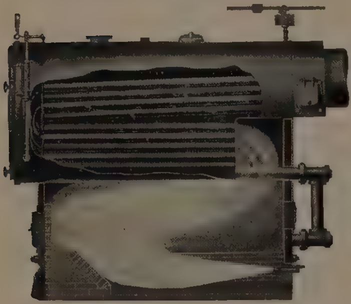
Waukegan, Illinois and Bristol, Pennsylvania



For Burning Soft Coal Smokelessly



For Soft or Hard Coal, Gas or Wood



For Burning Oil

PACIFIC

STEEL HEATING BOILERS

Pacific Steel Heating Boilers are built for steam or hot water heating using soft coal, hard coal, oil, gas, or wood as fuel.

They are constructed of steel according to the *A. S. M. E.* Code for building low pressure steel heating boilers. Every joint and seam in the Pacific is electrically welded and each boiler is built and tested to a pressure many times its normal working pressure under the supervision of an inspector stationed in our plant by one of the largest insurance companies.

Because of the compact design, Pacific Boilers often save from 25 to 40 per cent of the boiler room floor space required by other steel firebox boilers, (see dimensions given on opposite page).

The catalog ratings on Pacific Boilers are based on heating surface with steam at 2 lb. gauge pressure, hot water at 180 deg. at boiler. Any Pacific Boiler will carry its full rated load in direct cast iron radiation. Extra capacity must be allowed for exposed piping, storage tank, pipe coils or indirect radiators and for buildings where normal temperatures below 70 deg. fahr. are to be maintained.

PACIFIC SMOKELESS BOILERS

Catalogue Number	Net Rating	Height Water Line, Inches	Diameter Smoke Connec. Inches	Diameter Stack Inches	Minimum Height Stack, Feet	Grate Area, Square Feet	Heating Surface, Square Feet	Size of Outlet, Inches	Size of Return, Inches	Length Overall	Width Overall	Height Boiler	Length Base	Width Base	Height Base	Length for Ashpit	Width for Ashpit	Depth for Ashpit
6608	1400	61	14	13	55	6.5	131.4	5	3	62½	39	72½	46½	36	12	25	30	NOT LESS THAN SIX INCHES
6609	1650	61	14	13	55	6.5	149.0	5	3	68½	39	72½	52½	36	12	25	30	
6610	1900	61	14	13	55	7.3	166.6	5	3	74½	39	72½	58½	36	12	29	30	
6611	2150	61	14	13	60	8.1	184.2	5	3	80½	39	72½	64½	36	12	33	30	
6612	2400	61	14	13	60	9.0	201.8	5	3	86½	39	72½	70½	36	12	37	30	
6613	2800	68½	17	16	60	10.2	232.8	6	3	77½	43½	81½	58½	40¾	12	37	34¾	
6614	3400	68½	17	16	60	11.1	283.2	6	3	89½	43½	81½	70½	40¾	12	41	34¾	
6615	4000	68½	17	16	60	12.0	333.6	6	3	101½	43½	81½	82½	40¾	12	45	34¾	
614	4500	68½	18	17	60	12.70	372.0	6	3	106	49¼	79¼	88½	38	12	53	32	
615	5000	75½	18	17	60	12.07	392.0	6	3	96	58	89¼	76½	44	12	41	38	
616	5500	75½	18	17	65	13.10	425.0	6	3	102	58	89¼	82½	44	12	45	38	
617	5800	75½	18	17	65	15.15	457.6	6	3	108	58	89¼	88½	44	12	53	38	
618	6500	82¼	24	22	65	16.42	508.5	8	4	98	62½	96	76½	50½	12	49	44½	
619	7500	82¼	24	22	70	18.83	594.8	8	4	110	62½	96	88½	50½	12	57	44½	
620	8500	82¼	24	22	70	20.00	637.5	8	4	116	62½	96	94½	50½	12	61	44½	
621	9000	89½	26	24	70	19.11	708.7	8	4	112½	70½	106	88½	57½	12	49	51½	
622	10000	89½	26	24	75	20.50	809.5	8	4	124½	70½	106	100½	57½	12	53	51½	
623	12000	99½	30	28	75	25.14	864.5	8	4	113½	77½	117¾	88½	64	15	61	58	
624	14000	99½	30	28	75	26.64	988.8	8	4	125½	77½	117¾	100½	64	15	65	58	
625	15500	106	32	30	85	32.60	1183.8	8	5	127	86	125¾	100½	83½	15	57	77½	
626	18000	106	32	30	85	34.70	1332.9	8	5	139	86	125¾	112½	83½	15	61	77½	
627	20500	106	32	30	90	36.80	1482.0	10	6	151	86	125¾	124½	83½	15	65	77½	
628	22000	119	36	33	100	39.10	1583.1	10	6	144½	95½	140	113½	96½	18	61	90½	
629	25000	119	36	33	100	41.40	1759.0	10	6	156½	95½	140	125½	96½	18	65	90½	
630	28000	119	36	33	100	43.70	1934.9	10	6	168½	95½	140	137½	96½	18	69	90½	

For Pacific Direct Draft or Oil Fired Boilers use the above specification.

PACIFIC LOW WATER LINE DIRECT DRAFT AND SMOKELESS BOILERS

Catalogue Number	Net Rating	Height Water Line, Inches	Diameter Smoke Connec. Inches	Diameter Stack Inches	Minimum Height Stack, Feet	Grate Area, Square Feet	Heating Surface, Square Feet	Size of Outlet, Inches	Size of Return, Inches	Length Overall	Width Overall	Height Boiler	Length Base	Width Base	Height Base	Length for Ashpit	Width for Ashpit	Depth for Ashpit
2291	2100	59½	14	13	55	7.3	167	5	3	74½	39	71	52½	36	12	29	30	NOT LESS THAN SIX INCHES
2292	2300	59½	14	13	55	8.1	186	5	3	80½	39	71	58½	36	12	33	30	
2293	2500	59½	14	13	60	9.0	204	5	3	86½	39	71	64½	36	12	37	30	
2294	2700	59½	14	13	60	9.8	222	5	3	92½	39	71	70½	36	12	41	30	
2295	2900	59½	14	13	60	9.8	241	5	3	98½	39	71	76½	36	12	41	30	
2331	3500	68½	17	16	60	11.2	259	6	3	83½	43½	81½	58½	40¾	12	41	34¾	
2332	4100	68½	17	16	65	13.1	311	6	3	95½	43½	81½	70½	40¾	12	49	34¾	
2333	4850	68½	17	16	70	14.1	363	6	3	107½	43½	81½	82½	40¾	12	53	34¾	
2334	5500	68½	17	16	70	15.0	415	6	3	119½	43½	81½	94½	40¾	12	57	34¾	
2401	6200	68	18	17	70	18.8	466	6	3	118	50	79½	94½	47	12	61	41	
2402	7000	68	18	17	75	19.9	496	6	3	124	50	79½	100½	47	12	65	41	
2471	7650	78	22	21	70	20.8	563	8	4	108	58	91	82½	54	12	57	48	
2472	8200	78	22	21	75	20.8	604	8	4	114	58	91	88½	54	12	57	48	
2473	8750	78	22	21	75	22.1	646	8	4	120	58	91	94½	54	12	61	48	
2474	9250	78	22	21	80	23.4	687	8	4	126	58	91	100½	54	12	65	48	
2521	10000	82	24	23	80	23.0	753	8	4	122	62½	96	94½	59	12	57	53	
2522	12000	82	24	23	85	24.4	850	8	4	134	62½	96	106½	59	12	61	53	
2523	13000	82	24	23	90	25 9	899	8	4	140	62½	96	112½	59	12	65	53	
2600	14000	90	30	29	85	28.0	1022	8	4	124½	70½	106	94½	67	12	61	61	
2601	16000	90	30	29	90	28 0	1154	8	4	136½	70½	106	106½	67	12	61	61	
2602	17000	90	30	29	90	29.7	1219	8	4	142½	70½	106	112½	67	12	65	61	
2603	18600	90	30	29	95	31.4	1350	8	4	154½	70½	106	124½	67	12	69	61	
2671	20000	98½	32	31	95	33.3	1467	8	4	143½	78½	118	112½	75½	15	65	69½	
2672	22000	98½	32	31	100	35.2	1627	10	5	155½	78½	118	124½	75½	15	69	69½	
2673	24000	98½	32	31	110	37.1	1786	10	5	167½	78½	118	136½	75½	15	73	69½	
2674	26400	98½	32	31	115	37.1	1945	10	5	179½	78½	118	148½	75½	15	73	69½	
2751	28000	106	36	35	105	39.5	2073	10	5	157	86	126	124½	83½	15	69	77½	
2752	31000	106	36	35	110	41 6	2278	12	6	169	86	126	136½	83½	15	73	77½	
2753	34000	106	36	35	120	41 6	2482	12	6	181	86	126	148½	83½	15	73	77½	
8841	. . .	120	40	....	....	....	....	....	....	162½	95½	140	125½	96½	18	..	....	
8842	. . .	120	40	....	....	....	....	....	....	174½	95½	140	137½	96½	18	.	....	
8843	.....	120	40	....	....	....	....	....	....	186½	95½	140	149½	96½	18	...	.....	

Pacific Boilers are constructed with smoke outlet at the rear and all of the tubes, both upper and lower banks, are cleaned or removed from the front of the boiler through the front flue doors. Space at rear of boiler is not necessary.

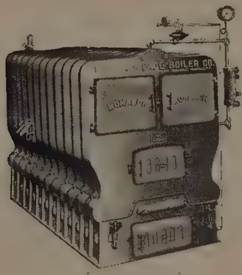
Complete catalog showing all types and sizes Pacific Boilers will be furnished on request.

The Wm. H. Page Boiler Co.

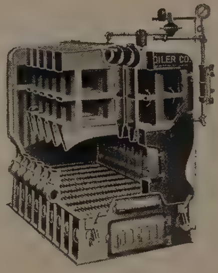
200 Madison Avenue, **New York**

Boston, 123 Beverly Street
Philadelphia, 1126 Washington Avenue
Cleveland, Rose Building
Meadville, Pa., Factory

Makers of Boilers for more than 70 Years



Monarch Smokeless



Monarch Water Tube

Monarch Sectional Steam and Water Boilers

No.	Rating Sq. Ft. Steam	Rating Sq. Ft. Water	‡Size of Grate Inches	‡Full Area of Grate Sq. Ft.	Height Overall Inches Steam	Width Overall Inches Steam	Height Overall Inches Water	Width Overall Inches Water	Length Inches	Water Line Inches Steam	Outlets and Inlets Inches	Size of Smoke Pipe Inches
4–22	850	1400	22 x 20	3.06	59	39¼	52	35	27⅜	41	2–3	13
5–22	1075	1775	22 x 26⅜	4.03	59	39¼	52	35	33⅞	41	2–3	13
6–22	1300	2150	22 x 32¾	5.00	59	39¼	52	35	39⅞	41	2–3	13
7–22	1525	2525	22 x 39⅛	5.98	59	39¼	52	35	46⅜	41	2–3	13
4–28	1600	2650	28 x 24¾	4.82	70½	45¼	62¾	41	35⅜	51	2–5	16
5–28	2100	3475	28 x 33⅛	6.45	70½	45¼	62¾	41	43⅜	51	2–5	16
6–28	2600	4300	28 x 41½	8.07	70½	45¼	62¾	41	51¾	51	2–5	16
7–28	3100	5125	28 x 49⅞	9.70	70½	45¼	62¾	41	60¼	51	2–5	16
8–28	3600	5950	28 x 58¼	11.32	70½	45¼	62¾	41	69	51	2–5	16
9–28	4100	6775	28 x 66⅝	12.96	70½	45¼	62¾	41	77⅛	51	2–5	16
5–40	3400	5600	40 x 33⅛	9.20	80	59¼	72½	55	43⅜	58	2–5	21
6–40	4200	6925	40 x 41½	11.52	80	59¼	72½	55	51¾	58	2–5	21
7–40	5000	8250	40 x 49⅞	13.85	80	59¼	72½	55	60¼	58	2–5	21
8–40	5800	9575	40 x 58¼	16.18	80	59¼	72½	55	69	58	2–5	21
9–40	6600	10,900	40 x 66⅝	18.50	80	59¼	72½	55	77⅛	58	2–5	21
10–40	7400	12,200	40 x 75	20.82	80	59¼	72½	55	85¼	58	2–5	21
11–40	8200	13,525	40 x 83⅜	23.13	80	59¼	72½	55	94	58	3–5	21
12–40	9000	14,850	40 x 91¾	25.50	80	59¼	72½	55	101⅞	58	3–5	21
6–60	6600	10,900	60 x 41½	17.29	81½	86¼	74¼	82	51¾	60	2–6	26
7–60	8200	13,525	60 x 49⅞	20.78	81½	86¼	74¼	82	60¼	60	2–6	26
8–60	9800	16,175	60 x 58¼	24.27	81½	86¼	74¼	82	69	60	2–6	26
9–60	11,400	18,800	60 x 66⅝	27.76	81½	86¼	74¼	82	77⅛	60	3–6	26
10–60	13,000	21,450	60 x 66⅝	‡31.25	81½	86¼	74¼	82	85¼	60	3–6	26
11–60	14,600	24,100	60 x 66⅝	‡34.74	81½	86¼	74¼	82	94	60	3–6	26
12–60	16,200	26,725	60 x 75	‡38.22	81½	86¼	74¼	82	101⅞	60	3–6	26
13–60	17,800	29,375	60 x 75	‡41.72	81½	86¼	74¼	82	110¼	60	3–6	26
14–60	19,400	32,000	60 x 75	‡45.20	81½	86¼	74¼	82	118¾	60	3–6	26
15–60	21,000	34,650	60 x 83⅜	‡48.69	81½	86¼	74¼	82	127½	60	3–6	26
16–60	22,600	37,300	60 x 83⅜	‡52.18	81½	86¼	74¼	82	135⅝	60	3–6	26
17–60	24,200	39,950	60 x 83⅜	‡55.67	81½	86¼	74¼	82	143¾	60	3–6	26
18–60	25,800	42,600	60 x 91¾	‡59.16	81½	86¼	74¼	82	152⅜	60	3–6	26
19–60	27,400	45,200	60 x 91¾	‡62.65	81½	86¼	74¼	82	160⅜	60	3–6	26
20–60	29,000	47,850	60 x 91¾	‡66.14	81½	86¼	74¼	82	168¾	60	3–6	26

Ratings, as given, are derived from tests made in accordance with the American Society of Heating and Ventilating Engineers' Low-Pressure Boiler Testing Code.

‡Grate areas are for entire length of firebox, but, unless otherwise ordered, these boilers will be shipped with bridgewall section to reduce grate to length in table of dimensions above.

Pierce Firebox Boilers

Built by

AMES IRON WORKS

Division of

Pierce, Butler & Pierce Manufacturing Corporation

OSWEGO, N. Y.

STEEL FIREBOX HEATING BOILERS

are built to comply with *A.S.M.E.* Code requirements

Their capacities range from 2000 to 30,000 sq. ft. direct cast iron column radiation. These boilers are of **riveted construction** for 15, 100 or 125 lb. steam pressure, or **all welded construction** for 15 lb. steam pressure. With **plain furnace** suitable for oil, gas or anthracite coal or **downdraft furnace** for bituminous coal.

The Company has established an enviable reputation and for 75 years have been building High Pressure Horizontal Tubular, Portable, Locomotive, Upright and Empire Boilers as well as all types of Steam Engines.

Send for Bulletins to obtain detail Specifications and Dimensions

Pierce, Butler & Pierce Mfg. Corp.

41 East 42nd Street, **New York City**

Branch Offices

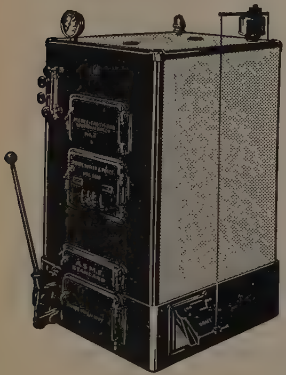
Akron, Ohio
Baltimore, Md.
Boston, Mass.
Cleveland, Ohio
Detroit, Mich.
Dover, N.J.
Forest Hills, N.Y.
Jacksonville, Fla.
Newark, N.J.
New Haven, Conn.
New London, Conn.
New York, N.Y.
Philadelphia, Pa.
Pittsburgh, Pa.
Richmond, Va.
Roanoke, Va.
Savannah, Ga.
Syracuse, N. Y.
Worcester, Mass.

Plants

Syracuse and Oswego, N.Y.
Huntingdon, Pa.
Zanesville, Ohio

Manufacturers of

Pierce American-Eastwood and Pebco-Cast Iron Heating Boilers
Ames-Steel Fire Box-Horizontal Tubular—for Heating and Power
Eastwood Screw Nipple Radiation, Valves, Gauges, Thermometers



RATINGS AND DIMENSIONS

Boiler No.	Rating Sq. Ft. Radiation		Grate Area Sq. Ft.	Length Over-all	Outlet No. Size	Inlets No. Size	Minimum Chimney Requirement
	Steam	Water					
2–04	700	1150	2.25	36½″	2–3″	2–3″	8″ x 8″ x 30′
2–05	900	1500	3.0	42½″	2–3″	2–3″	8″ x 12″ x 30′
2–06	1100	1850	3.75	48½″	2–3″	2–3″	8″ x 12″ x 35′
2–07	1300	2200	4.5	54½″	2–3″	2–3″	12″ x 12″ x 35′
2–08	1500	2550	5.25	60½″	2–3″	2–3″	12″ x 12″ x 35′

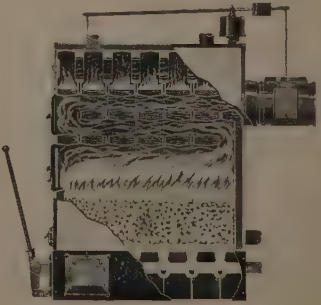
Heights overall 54 in. Width overall 31⅞ in.
Height water line steam boilers 42½ in.

3–05	1400	2350	4.16	47½″	2–3″	2–4″	8″ x 12″ x 35′
3–06	1800	3000	5.16	53½″	2–3″	2–4″	12″ x 12″ x 35′
3–07	2200	3650	6.16	59½″	3–3″	2–4″	12″ x 12″ x 40′
3–08	2600	4300	7.16	65½″	3–3″	2–4″	12″ x 16″ x 45′
3–09	3000	4950	8.16	71½″	4–3″	2–4″	16″ x 16″ x 45′
3–10	3400	5600	9.16	77½″	4–3″	2–4″	16″ x 16″ x 50′

Height overall 63 in. Width overall 38½ in.
Height water line steam boilers 52½ in.

The Eastwood Jacketed Sectional Boiler for Steam or Water

A Jacketed Boiler of Modern Design.
Flaming Orange Colored Steel Jacket.
Air Cell Insulation.
Long Fire Travel.
Large Fuel Capacity.
Efficient and Economical.
Low Chimney Requirements.
Burns Hard or Soft Coal, Coke.
Equally Adapted for Oil or Gas.



The Eastwood Screw Nipple Radiator

Harmonious in Design.
Rugged in Construction.
High in Heating Effect.

RATINGS AND DIMENSIONS

Style	Inches High	Rating Sq. Ft.	Height Floor to Center	
			Bottom Tap	Top Tap
3 Tube	38 32 26 20	3½ 3 2⅛ 1¾	4½″ 4½″ 4½″ 4½″	36¼″ 30¼″ 24¼″ 18¼″

Width of section 5⅛ in. Length 2½ in.

4 Tube	38 32 26 20	4¼ 3½ 2¾ 2¼	4½″ 4½″ 4½″ 4½″	36¼″ 30¼″ 24¼″ 18¼″

Width of section 7 in. Length 2½ in.

5 Tube	38 32 26 22 20	5 4⅛ 3½ 3 2⅔	4½″ 4½″ 4½″ 4½″ 4½″	36¼″ 30¼″ 24¼″ 20¼″ 18¼″

Width of section 8⅞ in. Length 2½ in.

7 Tube	38 32 26 22 17 14	7½ 6¼ 5 4 3 2½	4½″ 4½″ 4½″ 4½″ 4½″ 4½″	36¼″ 30¼″ 24¼″ 20¼″ 15¼″ 12¼″

Width of section 12⅝ in. Length 3 in.

The Pierce-Pebco-Jacketed Round Boiler

Flaming Orange Colored Steel Jacket.

Air Cell Insulation.

Three Piece Construction.

No Excessively Heavy Parts.

Practical and Efficient.

RATING AND DIMENSIONS

No.	Ratings Sq. Ft.		Grate Area Sq. Ft.	Outlets No. Size	Inlets No. Size	Chimney Required
	Steam	Water				
18	450	750	1.77	1-2½″	2-2½″	8″ x 8″ x 30′
20	600	1000	2.18	1-3″	2-2½″	8″ x 8″ x 30′
22	750	1250	2.64	1-3″	2-2½″	8″ x 8″ x 35′

Water line steam boilers 39⅛ in.
Height overall—all sizes 45 in.

RICHMOND RADIATOR COMPANY

INCORPORATED

Executive Office: 1480 Broadway, **New York**

Branch Offices

CHICAGO, 1010 Wrigley Building
PHILADELPHIA, 2241 North American St.
BOSTON, 460 Park Square Building
CLEVELAND, Cedar Avenue and Ashland Road

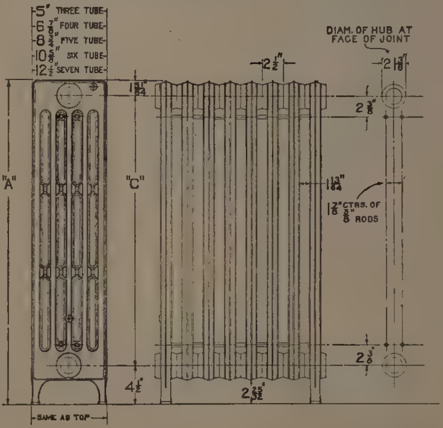
Gas Boiler Division: 2220 Chestnut Street, Philadelphia, Pa.
Radiator, Enameledware and Heatomat Plant, Uniontown, Pa.
Boiler Plant, Norwich, Conn.

The "RICHMOND"

A masterpiece of design. Greater heating surface and space between sections. No protuding surfaces. Tested at Frost Laboratories in accordance with code of A. S. H. & V. E. Three, four, five, six and seven tubes in several heights.

'RICHMOND' TUBE RADIATION

PUSH NIPPLE CONSTRUCTION



The Richmond Floorline Radiator

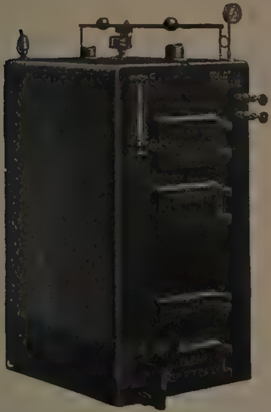
This illustration pictures a single floorline radiator attached to the baseboard. Note how valve at one end, and the outlet trap and pipe at the other are concealed.

This illustration pictures the floorline radiator completely recessed. A decorative grille covers the recess flush with the wall. With this radiator installed, there are no restrictions on decoration and furniture placement. Chairs, tables and other pieces may be placed close to this finer radiator without danger of injury.

"RICHMOND-MODEL"

INSULATED AND JACKETED SECTIONAL BOILER

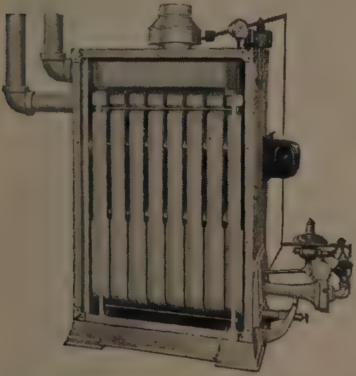
STEAM AND WATER



Available with or without smoke preventing device, made in widths of grates, 15 in. and 22 in.

"Richmond" Heavy Duty Smokeless Boilers

Designed for Fuel Economy. Burns all grades of Hard or Soft Coal, Coke, Lignite, Natural Gas and Fuel Oils. Meets the requirements of the most rigid Smoke Ordinances. A 51 in. Boiler, 7 to 16 Sections, Steam and Hot Water.



Outstanding features of the Richmond Heatomat Gas Boiler

Vertical Tubular Construction.

Preheating return water flow with flue gas heat.

Water cooled walls absorb burner heat.

Secondary air intake regulated with gas flow.

Heat transmission scientifically baffled.

Only one burner, one primary air setting for battery.

Model Sectional Boilers

For Steam and Hot Water. Three to twelve sections, 18, 22, 30 and 40 in. grates. Compact, accessible, efficient heating surface and circulation system.

Spencer Heater Company

Division of Lycoming Manufacturing Company
Makers of Spencer Heaters
Williamsport, Pa.

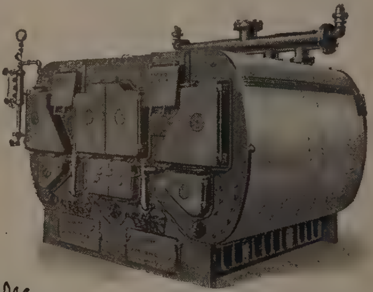
New York, N. Y. Philadelphia, Pa. Cincinnati, Ohio Syracuse, N. Y. Pittsburgh, Pa. Buffalo, N. Y.
Boston, Mass. Baltimore, Md. Albany, N. Y. Scranton, Pa. Chicago, Ill. Rochester, N. Y.

PRODUCTS: Spencer Magazine Feed Heaters

Spencer Heaters—The Spencer Heater is the original magazine feed heater with sloping grates. The water-jacketed magazine holds enough fuel for 12 to 24 hours, without attention. As fuel feeds automatically, as fast or as slow as the fire requires, the magazine supply lasts longer in milder weather.

Spencer Heaters are made in sizes to suit any building, large or small, either in steel tubular types or cast iron sectional types. *Commercial ratings have been discontinued.* Capacities are guaranteed when installed under normal conditions, according to the table below and on the following page, when used with any low pressure steam, vapor, or hot water system.

50 Series, Spencer Tubular Steam Heater
For large building work—an efficient magazine heater of combination water-tube and return tube construction



100 Series, Spencer Tubular Steam Heater
The largest type of Spencer Heater, a four-grate heater for use in multiple story buildings

Sizes and Guaranteed Capacities of Spencer Steel Tubular Heaters

	Heater No.	Direct Cast Iron Column Radiation Loads, Sq. Ft.*	Grate Area Sq. Ft.	Outlets, Number and Size, In.	Returns, Number and Size, In.	Size Chimney Flue In.—Ft.	Smoke Pipe Diameter, In.	Overall Dimensions, In.		
								Length	Width	Height
15-21 Series	15	1,600	12.00	2-4	2-3	18x18-50	16	72½	60	63¼
	17	1,950	13 00	2-4	2-3	18x18-55	16	78½	60	63¼
	19	2,300	15.00	2-4	2-3	18x18-60	16	84½	60	63¼
	20	2,650	16.50	2-4	2-3	18x18-60	16	90½	60	63¼
	21	3,000	18.00	2-4	2-3	18x18-60	16	96½	60	63¼
50 Series	3-45	3,600	18.05	2-5	1-4	18x18-50	18	75	81¼	71¾
	3-50	4,100	20 24	2-5	1-4	18x18-55	18	81¼	81¼	71¾
	3-55	4,600	22.56	2-5	1-4	18x18-60	18	87½	81¼	71¾
	3-60	5,100	24.83	2-5	1-4	20 diam.-65	18	93¾	81¼	71¾
	3-70	5,600	27.00	2-5	1-4	20 diam.-70	18	100	81¼	71¾
100 Series	3-80	6,500	30.35	1-8	2-4	24 diam.-65	22	68¾	116⅛	100¾
	3-90	7,600	34.70	1-8	2-4	24 diam.-65	22	75	116⅛	100¾
	3-105	8,700	39.05	1-8	2-4	30 diam.-65	22	81¼	116⅛	100¾
	3-120	9,800	43 40	1-8	2-4	30 diam.-70	22	87½	116⅛	100¾
	3-140	10,900	47.75	1-8	2-4	36 diam.-70	22	93¾	116⅛	100¾
	3-160	12,000	52.10	1-8	2-4	36 diam.-70	22	100	116⅛	100¾

*This includes ample provision for heat loss in covered mains, risers and returns, and for peak loads.
Heaters No. 3-45 to 3-160 are furnished with or without steel jackets and 1½-in. Rockwool asbestos covering, also pipe header.
Heaters No. 15-21 are furnished with inside steel jackets only.
Chimney flue sizes are based on a maximum flue temperature at boiler smoke outlet of 500 deg. fahr.

Special Features for Different Types of Buildings—Spencer Heaters are especially efficient in industrial buildings, greenhouses and garages where uniform heat is desirable; and in churches, theaters, schools and buildings where they give constant, even and uniform heat, without the attention of a night fireman.

For the home, the Spencer is especially convenient, as it needs attention only once or twice in 24 hours.

Spencer Economy for Building Owners—Though Spencer Heaters are designed to burn any non-coking graded fuel, their greatest saving is made with small sized, low cost fuels. They save as much as half the owner's annual fuel bill by using No. 1 buckwheat anthracite, and proportionately by using by-product pea coke. Where anthracite and coke are not available, they are equally efficient when fired with smaller sizes of semi-bituminous coal, such as Pocahontas, or any non-coking graded fuel.

Automatic Magazine Feed Gives Steady Heat—Fuel is fed automatically by gravity—no blowers or mechanical apparatus is required. They are easy to install—the new Spencer Heaters are as easy to erect as any other sectional heater on the market—and there is nothing to get out of order.

Write for complete descriptions and illustrations of all Spencer Heaters.

J-Type Spencer Sectional Heater
A magazine heater for steam, vapor or hot water systems for the small home

L-1 Type, Spencer Sectional Heater
A magazine heater for steam, vapor or hot water systems in dwellings or industrial buildings of moderate size

L-2 Type, Spencer Sectional Heater
A magazine heater for large dwellings, industrial buildings and institutional buildings

Sizes and Guaranteed Capacities of Spencer Cast Iron Sectional Heaters

	Heater No.	Direct Cast Iron Column Radiation Loads, Sq. Ft.*		Grate Area Sq. Ft.	Outlets, Steam and Water, Number and Size, In.	Returns, Steam and Water, Number and Size, In.	Size Chimney Flue In.—Ft.	Smoke Pipe Diameter In.	Overall Dimensions, In.		
		Steam	Water						Length	Width	Height
J Type	J 3	175	290	1.30	1-3	2-3	8x 8-35	8	27	24	45
	J 4	275	455	1.90	1-3	2-3	8x 8-35	8	34	24	45
	J 5	375	620	2.50	1-3	2-3	8x 8-35	8	41	24	45
L-1 Type	L 105	390	645	2.60	1-4	2-4	8x 8-35	10	39	32	57
	L 106	510	845	3.33	2-4	2-4	8x 8-35	10	46	32	57
	L 107	630	1045	4.07	2-4	2-4	8x12-35	10	53	32	57
	L 108	750	1245	4.80	2-4	2-4	8x12-35	10	60	32	57
L-2 Type	L 205	550	910	3.63	1-4	2-4	8x12-35	10	39	40	60
	L 206	725	1200	4 66	2-4	2-4	8x12-35	10	46	40	60
	L 207	900	1490	5 68	2-4	2-4	8x12-40	10	53	40	60
	L 208	1075	1780	6.70	2-4	2-4	12x12-40	10	60	40	60
	L 209	1250	2070	7.73	2-4	2-4	12x12-40	10	67	40	60
	L 210	1225	2360	8.75	2-4	2-4	12x12-45	10	74	40	60

*This includes ample provision for heat loss in covered mains, risers and returns, and for peak loads.
Spencer Cast Iron Sectional Heaters are furnished with or without jacketed covering.

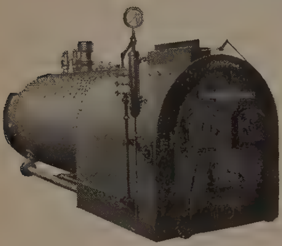
The Stanwood Corporation

Established 1891

Manufacturers of Stanwood Smokeless Boilers for Heating and Power Service and Horizontal Return Tubular Boilers.

Cincinnati, Ohio

Stanwood Smokeless Boilers



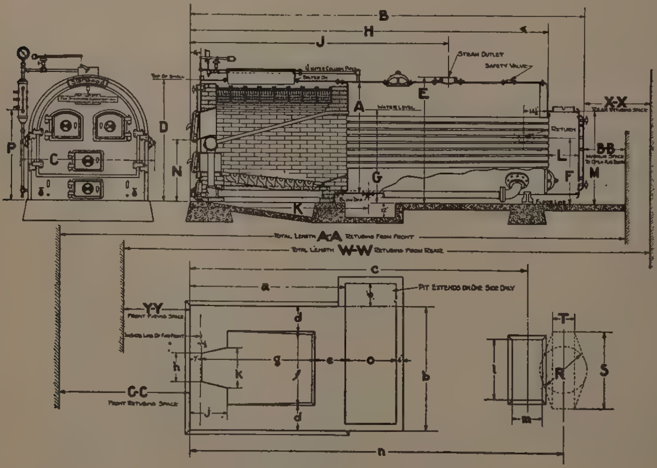
Low Water Line—An important feature of Stanwood Smokeless Boilers is the low water level from 48 to 75 in. depending upon size. This valuable characteristic for a heating boiler gives it wider application and is particularly appropriate where there is limited head room in the basement.

Shell cannot be bagged or burned nor can its circumferential seams be cracked. Nowhere are these surfaces exposed to the fire. Boiler has no firebox or mudlegs to fill up and corrode; no staybolts to rust or break off; no crownsheet to drop if water is low. There is no internal flue that can collapse.

High over-all efficiency due to high combustion and the smokeless performance of a down-draft furnace; low stack temperature, secured through rapid circulation, no air leaks and a minimum radiation loss.

Primarily intended to burn bituminous coal with down-draft furnace. Can also be operated with oil, gas, anthracite or coke.

Stanwood Smokeless Boilers are built in sizes from (3500 to 31,000 sq. ft. steam radiation) 29 to 250 hp. for working pressures of 15, 100, 125 and 150 lbs. Can be built for higher pressure if desired.



STANWOOD SMOKELESS BOILERS—STEEL-RIVETED

General Specifications and Dimensions

	Number of Boiler	†608	610	612	614	616	618	620	622	624	626	628
	Heating Capacity—Steam....Sq. Ft.	3500	5000	6000	8500	10000	12000	16000	18500	22000	26000	31000
	Heating Capacity—Water....Sq. Ft.	5600	8000	9600	13600	16000	19000	26000	30000	35000	42000	50000
	Horsepower......................	29	40	50	70	80	100	125	150	175	210	250
A	Diameter of Boiler Shell.........In.	44	54	54	60	66	72	78	84	90	90	90
B	Length of Boiler overall......Ft.-In.	14–6	15–10	18–10	18–11	19–6	19–7	19–8	20–4	20–8	24–0	26–0
C	Width of Boiler overall, maximum. In.	66	66	66	72	78	86	91	98	104	104	104
	Heating Surface.............Sq. Ft.	308	422	518	692	814	990	1260	1500	1774	2106	2540
	Upper Grate Surface.........Sq. Ft.	10½	14	17½	20	22	25	27½	33	36	39	42
	Lower Grate Surface.........Sq. Ft.	7½	12½	15¾	18	20	22½	25	30¼	33	36	39
	Openings—Steam Outlet...Diam. In.	5	6	6	6	8	8	8	8	8	10	10
	Return Inlet...Diam. In.	3	4	4	5	5	5	6	6	6	6	6
	Safety Valve...Diam. In.	2	2½	3	3	3½	3½	4	4½	2–3½	2–3½	2–4
	Blow-off or Drain Pipe........Diam. In.	1½	2	2	2	2	2	2	2½	2½	2½	2½
D	Height, Floor to top of Shell.....In.	64	64	64	67	73¼	79	85½	91¼	97	97	97
E	" " " Steam Outlet In.	61	66	66	69	75¼	82¼	87½	93¼	99½	99½	99½
F	" " Return Inlet......In.	36¼	36¼	36¼	36¼	39½	42¼	45½	48½	51½	51½	51½
G	" " Water Level.......In.	48	49¼	49¼	51	57	61	67	70¾	75	75	75
H	Front of Foundation to Back Head..............Ft.-In.	13–1½	14–2½	17–2½	17–2½	17–9	17–9	17–9	18–3	18–3	21–5	22–11
J	Steam Outlet............Ft.-In.	9–4½	10–11½	12–3½	12–3½	12–10	12–10	12–10	13–4	13–4	16–4	17–4
K	Blow-off ....Ft.-In.	6–5	7–1¼	8–1¼	8–1¼	9–1	9–1	9–1	9–7	9–7	10–1	10–7
L	Depth of Smoke Box............In.	15	16½	16½	17½	18¼	19½	20½	22½	26¼	27	33
M	Height, Floor to Base of Stack Saddle.......................In.	58½	49¾	49¾	51¾	56	61¼	67½	71¼	77	77	77
N	Height, Floor to Upper Fire Door..In.	37¼	37¼	37¼	36¾	39¼	39¼	42½	41½	47	47	47
R	Stack, Diam. and Height, minimum for 1 Boiler..............In.xFt.	20x55	22x55	24x60	26x65	28x65	30x70	32x70	34x80	36x90	39x100	42x100
	Breeching Diam. for 1 Boiler.....In.	22	24	26	28	30	32	34	36	38	42	44
	Stack Diam. and Height for 2 Boilers, minimum.............. In.xFt.	30x65	32x65	32x70	34x70	36x75	42x80	46x80	48x90	50x100	54x100	60x100
	Breeching Diam. for 2 Boilers....In.	32	34	34	38	38	46	50	52	54	58	64
T-S	Sizes of Rectangular Stack Saddle. In.	*9x34	11x36	11x36	12x42	13x46	14x52	15x58	17x64	21x60	22x70	25x70
	No. of Straight Fire Brick...Approx.	350	325	390	440	760	630	725	780	970	1000	1090
	" Split Fire Brick......Approx.	14	14	20	20	20	20	20	20	20	22	26
	" No. 1 Arch Fire Brick. Approx.	60	100	130	130	110	100	120	120	170	180	210
	" Sil-o-cel Brick.......Approx.	75	50	60	75	100	150	150	250	300	325	375
	" Common Red Brick..Approx.	100	210	220	275	400	475	600	500	600	625	675
	Outside Insulated Covering...Sq. Ft.	180	200	235	255	290	315	345	376	410	500	560
	Boilers in pairs, center to center...In.	78	78	78	84	90	96	102	108	114	114	114
	Total Weight (approximate) No Stack or Brickwork.........Lbs.	9000	10700	11600	13900	17500	19400	24000	25700	28500	32000	36000

Standard Foundation Dimensions and Space Required for Installing

Size	Foundation														Retubing From (See Note ‡)					
	Dimensions—Feet and Inches														Front			Rear		
	a	b	c	d	e	f	g	h	j	k	l	m	n	o	A-A	B-B	C-C	W-W	X-X	Y-Y
608	5–6	5–4	12–0	16	19	32	3–4	17	22½	24	30	12	13–10½	2–6	23– 9	25	7–2	27– 4	6–10	6–0
610	6–3	5–8	13–3	15	18	38	4–2	17	22½	24	30	12	14–11	2–6	25– 5	29	7–2	28– 8	6–10	6–0
612	7–3	5–8	16–3	15	18	38	5–2	17	22½	24	30	12	17–11	2–6	30– 4	29	9–1	35– 8	8–10	8–0
614	7–3	6–2	16–3	15	18	44	5–2	17	22½	24	30	12	17–11½	2–6	30– 4	32	8–9	35– 8	8– 9	8–0
616	7–9	6–8	16–9	18	18	44	5–8	17	22½	24	30	12	18– 6	2–6	31–11	35	9–6	37– 9	8– 9	9–6
618	7–9	7–3	16–9	18	18	51	5–8	17	22½	24	36	18	18–6½	2–6	32– 3	38	9–6	37– 8	8– 7	9–6
620	7–9	7–9	16–9	18	18	57	5–8	17	22½	24	36	18	18– 7	2–6	32– 7	41	9–6	37– 9	8– 7	9–6
622	8–3	8–3	17–3	18	18	63	6–2	40	22½	48	36	18	19– 2	2–6	34– 0	44	10–0	38– 8	8– 4	10–0
624	8–9	8–9	17–3	18	18	69	6–8	40	22½	48	48	24	19– 4	2–6	34– 7	47	10–0	39– 0	8– 4	10–0
626	9–3	8–9	20–6	18	18	69	7–2	40	22½	48	48	24	22–10	2–6	40– 5	47	12–6	46– 4	11– 4	11–0
628	9–9	8–9	22–0	18	18	69	7–8	40	22½	48	48	24	24– 7	2–6	43– 5	47	13–6	49–10	12– 4	11–6

'Each of these boilers will carry its full rated load in direct cast iron radiation, or the equivalent thereof, provided sufficient radiation is installed to heat to the required temperature.

*Oval Ends used on 608 size only.

†Handhole under tubes in rear head on 608 size only. All other sizes with 11 x 15 manhole.

Trimmings furnished with 15 lbs. Boilers.

Water column with gage cocks (no column piping furnished), steam gage with siphon and cock; pop safety valves. Automatic Damper Regulator with lever, weight, chain and angle valve, wrench for header plugs. Firing tools include hoe, poker, slice bar, tube scraper and brush.

‡If space lengthwise is limited provision may be made for rear retubing by providing opening opposite rear end of boiler through which tubes may be withdrawn. Then dimension X-X may be reduced to B-B. Otherwise boiler may be retubed from front by allowing space C-C in front of boiler. Where installation limits are close or in question, consult our Engineering Department.

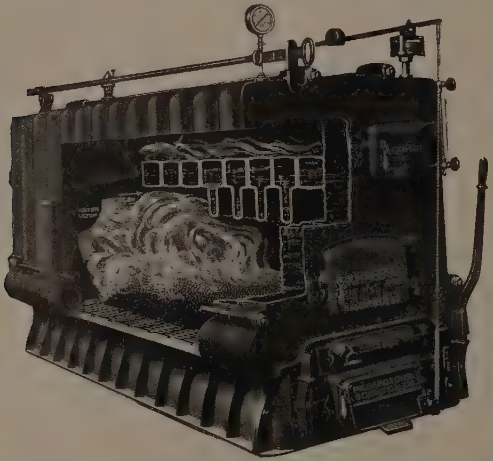
Richardson & Boynton Co.

Manufacturers of "Richardson" "Perfect" Heating and Cooking Apparatus since 1837

260 Fifth Avenue, **New York City**

New York Utica Newark Philadelphia Boston Chicago Buffalo
Minneapolis Cincinnati Detroit Providence

RICHARDSON HOT BLAST SMOKELESS BOILERS



Richardson Hot Blast Smokeless boilers are made in sectional form and can be erected at any time in old or new buildings.

"Y" flue construction equalizes the circulation and assures a steady water line.

Overhanging prime heating surfaces are at the maximum, producing the highest evaporating power.

The base is made in sections, permitting enlargement of the boiler if necessary.

SMOKELESS SECTIONAL

No.	Rating Sq. Ft.	Rating Sq. Ft.	Grate Area Sq. Ft.	Length Overall	Water Line In. Stm.	Smoke Pipe Inches	Ash Pit (Inside) Inches	Steam Outlets Inches	Water Outlets Inches	Steam and Water Inlets (Rear Section)
3207	3500	5600	10.00	64¼	48	14	38⅞ x 47½	3–4	3–4	2–4
3208	4050	6450	11.67	71⅝	48	14	38⅞ x 54⅞	3–4	3–4	2–4
3209	4600	7300	13.34	79	48	14	38⅞ x 62¼	4–4	4–4	2–4
3210	5150	8150	15.01	86⅜	48	14	38⅞ x 69⅝	4–4	4–4	2–4
3907	5150	8150	13.80	73	56	16	44⅞ x 53¾	3–5	3–5	2–5
3908	5950	9400	16.10	81⅜	56	16	44⅞ x 62⅛	3–5	3–5	2–5
3909	6750	10650	18.40	89¾	56	16	44⅞ x 70½	4–5	4–5	2–5
3910	7550	11900	20.70	97⅜	56	16	44⅞ x 78⅞	4–5	4–5	2–5
745	6750	10800	15.90	75	59	20	50¾ x 53¾	3–5	3–5	2–5
845	7700	12300	18.55	83⅜	59	20	50¾ x 62⅛	3–5	3–5	2–5
945	8650	13800	21.20	91¾	59	20	50¾ x 70½	4–5	4–5	2–5
1045	10600	15300	23.85	100⅛	59	20	50¾ x 78⅞	4–5	4–5	2–5
1145	11550	16800	23.85	108½	59	20	50¾ x 87¼	5–5	5–5	2–5
1245	12500	18300	23.85	116⅞	59	20	50¾ x 87¼	5–5	5–5	2–5
1345	13450	19800	23.85	125¼	59	20	50¾ x 87¼	6–5	6–5	2–5
1445	14500	21300	23.85	133⅝	59	20	50¾ x 87¼	6–5	6–5	2–5
1545	15450	22800	23.85	142	59	20	50¾ x 87¼	7–5	7–5	2–5
1645	16400	24300	23.85	150⅜	59	20	50¾ x 87¼	7–5	7–5	2–5
1745	17350	25800	23.85	158¾	59	20	50¾ x 87¼	8–5	8–5	2–5
1845	18300	27300	23.85	167⅛	59	20	50¾ x 87¼	8–5	8–5	2–5
1945	19250	28800	23.85	175½	59	20	50¾ x 87¼	9–5	9–5	2–5
2045	20200	30300	23.85	183⅞	59	20	50¾ x 87¼	9–5	9–5	2–5

The Titusville Iron Works Company

Titusville, Pennsylvania

Manufacturers of Riveted and Welded Steel Fire-Tube Boilers for Power and Heating; Fronts, Grates, Castings, Smoke Stacks, Tanks and Oil Field Boilers; Steam, Gas, Oil and Gasoline Engines; Pumping Powers and Oil Well Machinery

New York.........285 Madison Ave.
Syracuse.........345 W. Jefferson St.
Pittsburgh....Farmers Bank Bldg.
Wash., D.C., 201 Woodward Bldg,
Detroit, 2842 West Grand Blvd.
Richmond...............204 N. Jefferson St.
Fort Worth......709 Pennsylvania Ave.
Jacksonville...................P. O. Box 929
Buffalo..........1124 Marine Trust Bldg.
Chicago............332 S. Michigan Ave.
St. Louis....401 Bank Commerce Bldg.
Los Angeles...........940 Maple Ave.
Charlotte...............705 Realty Bldg.
New Orleans....612 Godchaux Bldg.
Atlanta......397 Peachtree St., N. E.
Phila., N.W. cor. 3rd and Arch Sts.

Facilities—Titusville Iron Works Company maintains one of the largest and best equipped boiler shops in the country. Every practicable mechanical provision is made for the bending, flanging, riveting, and electric welding so essential to high-grade products.

Construction—In addition to being thorough in engineering design, Titusville Boilers are built by men experienced in every detail of their particular operations.

All riveting is done by competent steel workers and all welding is done exclusively by experts who do nothing but welding. Wherever possible Titusville Welded Boilers are welded *inside* as well as outside. All workmanship and materials are guaranteed first class.

A. S. M. E. Code—Our boilers are built in strict accordance with the latest *A. S. M. E.* Boiler Code Standards and to local requirements when specified.

Inspection and Test—Titusville Boilers are continually inspected during construction by a resident representative of the Hartford Steam Boiler Inspection and Insurance Company, Hydrostatic tests are made upon completion. Insurance company certificate furnished free of charge on request.

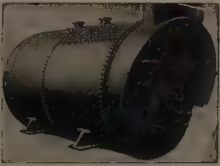
Working Pressures—Our boilers are built in two-pressure ranges, i.e., 100–250 lb. working pressure, *A. S. M. E.* Code, for power and high-pressure service, and in 15 lb. working pressure *A. S. M. E.* Code, for heating service.

Grates, Stacks, Etc.—All boilers are provided with complete sets of doors, fronts, castings, etc., as illustrated and of the types which are standard for our boilers. Special grates furnished on request.

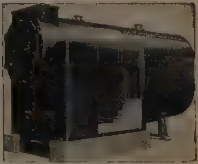
This company also offers its facilities for the construction of stacks, breechings and steel plate work.

Catalogs—Descriptive catalogs of our boilers and equipment will be sent upon request.

Perfection Down Draft Smokeless Boiler



Titusville Standard Internal Fired Scotch Type Boiler



Titusville Perfection Boiler—Built in Sizes 25 H. P. to 200 H. P. from 15 lbs. to 150 lbs. Working Pressure

Titusville Vertical Tubular Boiler

Welded Type Boiler

Tico Return Tubular Fire Box Boiler

Titusville Standard Tubular Boiler

Tico Smokeless Boiler

UNITED STATES RADIATOR CORPORATION

GENERAL OFFICES: DETROIT, MICHIGAN

Manufacturers of Capitol Boilers and Radiators

Branches and Sales Offices

*Baltimore, Md.
*Birmingham, Ala.
*Boston, Mass.
Buffalo, N. Y.
*Cambridge, Mass.
*Chicago, Ill.
*Cincinnati, Ohio
*Cleveland, Ohio
*Columbus, Ohio
*Davenport, Iowa
*Denver, Colo.
*Des Moines, Iowa
Detroit, Mich.
*Harrison, N. J.
*Indianapolis, Ind.
*Kansas City, Mo.
*Los Angeles, Cal.
*Louisville, Ky.
*Maspeth, L. I., N. Y.
*Milwaukee, Wis.
*New Haven, Conn.
*New Rochelle, N. Y.
New York, N. Y.
*Omaha, Neb.
*Philadelphia, Pa.
*Pittsburgh, Pa.
*Portland. Me.
*Portland, Ore.
*Providence, R. I.
*Reading, Pa.
*Rochester, N. Y.
*San Francisco, Cal.
*Seattle, Wash.
*Springfield, Mass.
*St. Louis, Mo.
*St. Paul, Minn.
*Troy, N. Y.
Washington, D. C.

*Assembling Plants located at points indicated by asterisk

Manufacturing Plants Located in Following Cities

Bristol, Pa.; Corry, Pa.; Detroit, Mich.; Dunkirk, N.Y.; Edwardsville, Ill.; Geneva, N.Y.; Waukegan, Ill.; West Newton, Pa.

CAPITOL BOILERS

In choosing the correct size of boiler for any building there is one and only one consideration: will it properly heat the required number of square feet of radiation?

The net cast iron radiating surface that each type and size of Capitol Boiler will heat adequately has been determined and is guaranteed in writing.

When the needed radiating surface is known and contributing factors checked, the selection of the proper Capitol Boiler becomes a simple matter.

GUARANTEE

The United States Radiator Corporation will give an absolute guarantee, in writing that Capitol Boilers will properly heat their full published amounts of "direct cast iron radiation," provided only, that the boilers are connected to correctly installed systems and that the recognized standard requirements are followed. Should any Capitol Boilers not meet these conditions, the additional capacity necessary will be supplied "without charge" by the United States Radiator Corporation.

CAPITOL RED CAP BOILERS

Capitol Red Cap Boiler

The Capitol Red Cap Boiler offers the latest development in round boilers. Built upon the precise principle of the Capitol Round Boiler, it is enclosed in a round jacket of cobalt blue, capped with cardinal red and fitted with red vitreous porcelain enamel doors. A thick blanket of rock wool, more effective than any insulation used heretofore, on jacketed boilers, insulates the entire boiler.

An ample base allows no ashes to choke the draft. An unusually deep firepot permits long firing periods. Large and stream lined water-ways and extra long fire travel insure high efficiency.

RADIATOR LOADS AND DIMENSIONS FOR CAPITOL RED CAP BOILERS

Boiler No.	Direct Cast Iron Radiator Loads, *Sq. Ft.		Height of Water Line, Inches	Grate Area, Sq. Ft.	Hard Coal Fuel Capacity, Pounds	Size of Outlet and Inlet, †Inches	Minimum Chimney Sizes	
	Steam	Water					Height Feet	Dimensions Inches
17–4	200	330	46$\frac{7}{8}$	1.44	139	2$\frac{1}{2}$	30	8 x 8
17–5	250	415	51$\frac{11}{16}$	1.44	139	2$\frac{1}{2}$	30	8 x 8
19–4	300	495	46$\frac{7}{8}$	1.76	170	2$\frac{1}{2}$	30	8 x 12
19–5	350	580	51$\frac{11}{16}$	1.76	170	2$\frac{1}{2}$	35	8 x 12
20–4	400	660	46$\frac{7}{8}$	2.24	227	3	30	8 x 12
20–5	450	745	51$\frac{11}{16}$	2.24	227	3	35	8 x 12
22–4	500	825	46$\frac{7}{8}$	2.76	297	3	35	8 x 12
22–5	550	910	51$\frac{11}{16}$	2.76	297	3	35	8 x 12
25–4	625	1030	47$\frac{1}{2}$	3.54	368	3$\frac{1}{2}$	35	8 x 12
25–5	675	1115	52$\frac{5}{16}$	3.54	368	3$\frac{1}{2}$	40	8 x 12
25–6	725	1195	57$\frac{1}{8}$	3.54	368	3$\frac{1}{2}$	40	8 x 12
28–4	775	1280	48$\frac{1}{2}$	4.40	479	4	35	8 x 12
28–5	850	1405	53$\frac{5}{16}$	4.40	479	4	40	12 x 12
28–6	925	1525	58$\frac{1}{8}$	4.40	479	4	45	12 x 12

*See Guarantee.
†Steam boilers have one outlet and two inlets.
Water boilers have two outlets and two inlets.

CAPITOL RED TOP BOILERS

Like the Red Cap, the Red Top possesses all the characteristics that mark the Capitol group of jacketed boilers. It has the same sturdy jacket of heavy gauge steel, with baked enamels in cobalt blue and cardinal red. Its trimmings are of nickel plate and black enamel. Its doors are vitreous porcelain enamel. Its insulation, sides, top and *back* is of full inch thick, wire reinforced, rock wool.

Capitol Red Top Boiler

A new boiler throughout, the Capitol Red Top includes many features which are distinct improvements in boiler design. Every part of the boiler has been given painstaking thought and extreme manufacturing care.

The Red Top is also made in smokeless type for burning bituminous coals. The same design, that has been used so successfully in Capitol Smokeless Boilers, is embodied in the Smokeless Capitol Red Top, and gives you every assurance of smokeless performance.

RATIONS AND DIMENSIONS
"A" Series for All Fuels

Boiler No.	Direct Cast Iron Radiator Loads, *Sq. Ft. Stm.	Direct Cast Iron Radiator Loads, *Sq. Ft. W.	Height of Water Line, Inches	Grate Area, Sq. Ft.	Coal Capacity, Cu. Ft.	Outlets	Inlets	Minimum Chimney Sizes Height, Feet	Minimum Chimney Sizes Dimen., Inches
A- 6	280	460	42½	1.96	2.78	1-4"	2-3"	30	8x12
A- 7	355	585	42½	2.45	3.47	1-4"	2-3"	30	8x12
A- 8	430	710	42½	2.94	4.16	1-4"	2-3"	35	8x12
A- 9	505	835	42½	3.43	4.86	1-4"	2-3"	35	8x12
A-10	580	960	42½	3.92	5.55	1-4"	2-3"	35	8x12
A-11	655	1085	42½	4.41	6.25	1-4"	2-3"	40	8x12

Height including trimmings 59⅝ in.; width 32⅞ in.

"B" Series Anthracite—For All Fuels

Boiler No.	Stm.	W.	Height of Water Line, Inches	Grate Area, Sq. Ft.	Coal Capacity, Cu. Ft.	Outlets	Inlets	Height, Feet	Dimen., Inches
B- 6	550	910	46½	3.60	6.1	1-4"	2-4"	35	8x12
B- 7	735	1215	46½	4.50	7.7	1-4"	2-4"	35	12x12
B- 8	920	1520	46½	5.40	9.1	2-4"	2-4"	35	12x12
B- 9	1105	1825	46½	6.30	10.6	2-4"	2-4"	40	12x12
B-10	1290	2130	46½	7.20	12.1	2-4"	2-4"	40	12x16
B-11	1475	2435	46½	8.10	13.6	2-4"	2-4"	45	12x16
B-12	1660	2740	46½	9.00	15.1	2-4"	2-4"	45	12x16

Height including trimmings 65⅞ in.; width 42⅝ in.

"B" Series Smokeless—For Soft Coal

Boiler No.	Stm.	W.	Height of Water Line, Inches	Grate Area, Sq. Ft.	Coal Capacity, Cu. Ft.	Outlets	Inlets	Height, Feet	Dimen., Inches
B- 9	1105	1825	46½	6.30	....	2-4"	2-4"	40	12x12
B-10	1290	2130	46½	7.20	....	2-4"	2-4"	40	12x16
B-11	1475	2435	46½	8.10	....	2-4"	2-4"	45	12x16
B-12	1660	2740	46½	9.00	....	2-4"	2-4"	45	12x16
B-13	1845	3045	46½	9.90	....	2-4"	2-4"	50	12x16
B-14	2030	3350	46½	10.80	....	3-4"	2-4"	50	12x16

Height including trimmings 65⅞ in.; width 42⅝ in.
*See Guarantee.

CAPITOL SMOKELESS BOILERS

"Smokeless" simply means complete combustion. And all of the carbon which forms smoke cannot be burned without the correct amount of air, oxygen.

The auxiliary inlets that supply air for complete combustion in Capitol Smokeless Boilers are not dependent upon the skill, guesswork or memory of the fireman.

No. 1150 Capitol Smokeless Boiler

Their size for each boiler rating is definitely determined in the Capitol Testing Laboratory and permanently fixed at the factory. They need no adjusting. The intensity of the fire itself governs the amount of air drawn in. To further assure accuracy, every Capitol auxiliary inlet is always an integral part of a single boiler section and is never placed between two sections where faulty assembly will cause a variance.

RADIATOR LOADS AND DIMENSIONS FOR SMOKELESS BOILERS

Boiler No.	Direct Cast Iron Radiator Loads, *Sq. Ft. Steam	Direct Cast Iron Radiator Loads, *Sq. Ft. Water	Height of Water Line, Inches	Grate Area, Sq. Ft.	Coal Capacity, Cu. Ft.	Outlets and Inlets	Minimum Chimney Sizes Height, Feet	Minimum Chimney Sizes Dimen., Inches
520	600	990	46½	3.48	4.32	2-3"	40	12x12
620	800	1320	46½	4.37	5.42	2-3"	40	12x12
720	1000	1650	46½	5.26	6.52	3-3"	45	12x16
820	1200	1980	46½	6.15	7.62	3-3"	45	12x16

*See Guarantee.
Height including trimmings 66½ in.; width 45 in.
Specify if back or top outlet smoke hood is required.

(Continued on following page)

(Continued from preceding page)

Boiler No.	Direct Cast Iron Radiator Loads, *Sq. Ft.		Height of Water Line, Inches	Grate Area, Sq. Ft.	Coal Capacity, Cu. Ft.	†Outlets and Inlets	Minimum Chimney Sizes	
	Steam	Water					Height, Feet	Dimen., Inches
627	1000	1650	45½	5.32	7.93	2–4″	40	12x12
727	1225	2020	45½	6.55	9.75	2–4″	40	12x12
827	1450	2390	45½	7.78	11.37	3–4″	45	12x12
927	1675	2760	45½	9.01	13.09	3–4″	45	12x16
1027	1900	3135	45½	10.24	14.81	3–4″	45	12x16
1127	2125	3505	45½	11.47	16.53	3–4″	50	12x16
1227	2350	3875	45½	12.70	18.25	4–4″	50	12x16

*See Guarantee.

†Outlets only. Two 4-in. inlets are located in the rear of the back section of 27-in. series.

Height including trimmings 68½ in.; width 50¾ in.

Specify if back or top outlet smoke hood is required.

740	2500	4125	49	8.15	10.40	2–5″	50	18x18
840	3000	4950	49	10.31	13.30	2–5″	55	18x20
940	3500	5775	49	10.31	13.30	2–5″	60	20x20
1040	4050	6680	49	12.47	16.30	3–5″	65	20x24
1140	4500	7425	49	14.63	19.25	3–5″	70	24x24
1240	4900	8085	49	14.63	19.25	3–5″	70	24x28
1340	5400	8910	49	16.79	22.20	3–5″	75	24x28

†Outlets only. Two 6 in. inlets are located in the rear of the back section of 40-in. series.

Height including trimmings 71 in.; width 75 in.

750	4700	7755	66	18.29	29.67	3–5″	55	24x24
850	5350	8825	66	21.33	34.68	4–5″	60	24x24
950	5850	9655	66	21.33	34.68	4–5″	65	24x28
1050	6500	10725	66	24.37	39.69	5–5″	70	24x28
1150	7000	11550	66	24.37	39.69	6–5″	80	28x28
1250	7650	12620	66	27.41	44.71	6–5″	90	28x32
1350	8150	13450	66	27.41	44.71	6–5″	95	32x32

Height including trimmings 92 in.; width 82 in.

Specify if back or top outlet smoke hood is required.

CAPITOL BOILERS—SQUARE TYPE
FOR HARD COAL

In this group of Capitol Boilers is presented a wide range of sizes from the smallest, the 200 series designed to provide full boiler efficiency in the smallest space, to the largest, the WN 270 series designed and built for heavy-duty work.

Many years of service in buildings of every nature throughout the United States have established a reputation for these boilers which is unsurpassed. Contribution factors to the remarkable ease of operating and efficiency of performance are the spacious ashpit; the correct proportioning of draft openings; the long fire travel and the scientific shaping of the direct and indirect heating surfaces; the durable easy shaking and dumping grates; the big doors the easily cleaned flues.

No. 4111 Capitol Steam Boiler

The exceptionally low water line of certain sizes permits foundations less deep than usual—an especially important economy where water, sand or rock makes excavating difficult and expensive.

RADIATOR LOADS AND DIMENSIONS FOR HARD COAL BOILERS

Boiler No.	Direct Cast Iron Radiator Loads, *Sq. Ft.		Height of Water Line, Inches	Grate Area, Sq. Ft.	Coal Capacity, Cu. Ft.	†Outlets and Inlets	Minimum Chimney Sizes	
	Steam	Water					Height, Feet	Dimen., Inches
204	350	580	46½	2.59	4.36	2–3″	35	8x12
205	500	825	46½	3.48	5.85	2–3″	35	8x12
206	625	1030	46½	4.37	7.34	2–3″	35	12x12
207	750	1240	46½	5.26	8.83	3–3″	40	12x12

*See Guarantee.

Height including trimmings 66½ in.; width 45 in.

G276	800	1320	45½	5.32	7.93	2–4″	40	12x12
G277	980	1620	45½	6.55	9.65	2–4″	40	12x12
G278	1160	1920	45½	7.78	11.37	3–4″	45	12x12
G279	1350	2220	45½	9.01	13.09	3–4″	45	12x12

†Outlets only. Two 4-in. inlets are located in the rear of the back section of G270 series boilers.

Height including trimmings 68½ in.; width 50¾ in.

235	1200	1980	55	7.28	11.01	2–4″	40	12x16
236	1500	2475	55	9.11	13.75	2–4″	45	12x16
237	1800	2970	55	10.94	16.49	3–4″	45	16x16
238	2100	3465	55	12.77	19.22	3–4″	50	16x16
239	2400	3960	55	14.61	21.96	3–4″	50	16x16
240	2500	4125	55	16.44	24.70	4–4″	60	16x16

Height including trimmings 78 in.; width 58¼ in.

4106	2000	3300	49	10.31	13.30	2–5″	45	18x18
4107	2500	4125	49	12.47	16.30	2–5″	50	18x18
4108	3000	4950	49	14.63	19.25	2–5″	55	18x20
4109	3500	5775	49	16.79	22.25	3–5″	60	20x20
4110	4000	6600	49	18.95	25.20	3–5″	65	20x24
4111	4500	7425	49	21.11	28.20	3–5″	70	24x24

†Outlets only. Two 6-in. inlets are located in the rear of the back section of 4100 series boilers.

Height including trimmings 71 in.; width 75 in.

WN276	3700	6105	66	15.25	24.66	3–5″	50	20x24
WN277	4300	7095	66	18.29	29.67	3–5″	55	24x24
WN278	4900	8085	66	21.33	34.68	3–5″	60	24x24
WN279	5500	9075	66	24.37	39.69	4–5″	60	24x24
WN280	6100	10065	66	27.41	44.71	4–5″	65	24x28
WN281	6700	11055	66	30.45	45.96	4–5″	70	28x28
WN282	7300	12045	66	30.45	47.21	4–5″	70	28x28
WN283	7900	13035	66	30.45	48.46	5–5″	75	28x32
WN284	8500	14025	66	30.45	49.72	5–5″	80	32x32

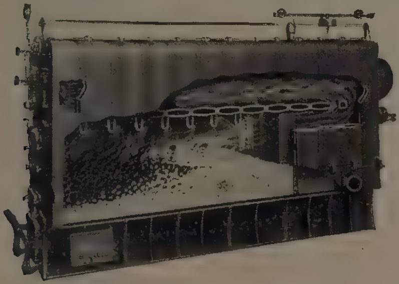
Height including trimmings 92 in.; width 82 in.

Weil-McLain
SCIENTIFIC COMBUSTION
BOILERS

WEIL-McLAIN COMPANY

Manufacturing Division
Michigan City, Ind., Erie, Pa.

General Offices
Chicago, Ill.



Smokeless Type

Weil-McLain Long Firing Period Smokeless Boilers are now making smokelessness popular with everyone—for three primary reasons:—

First: They require considerably less firing attention than smokeless boilers in general.

Second: They are simple to fire.

Third: They are not limited to free burning types of soft coal for effective operation.

STEAM		WATER		Area Complete Firebox at Grate Sq. Ft.	Net Area of Fuel Grates Sq. Ft.	Water Line Height Inches	Outlets and Inlets Number and Size Each Inches	Recommended Chimney Sizes
Size	Rating Sq. Ft.	Size	Rating Sq. Ft.					
722-S	1810	722-W	2990	7.03	4.88	46	2-3½	12x12x40
822-S	2105	822-W	3475	8.11	5.96	46	3-3½	12x12x45
922-S	2400	922-W	3960	9.19	5.96	46	3-3½	12x12x50
1022-S	2695	1022-W	4445	10.26	7.03	46	4-3½	12x12x55
752-S	2460	752-W	4060	8.10	5.70	51	2-3½	12x12x45
852-S	2995	852-W	4940	9.30	6.90	51	3-3½	12x16x45
952-S	3530	952-W	5825	10.50	6.90	51	3-3½	16x16x45
1052-S	4065	1052-W	6710	11.70	8.10	51	4-3½	16x16x50
782-S	4210	782-W	6950	11.47	7.97	55	2-4	16x16x50
882-S	5060	882-W	8350	13.22	9.72	55	3-4	16x16x55
982-S	5800	982-W	9570	14.97	11.47	55	3-4	16x20x55
1082-S	6550	1082-W	10,810	16.72	13.22	55	4-4	16x20x60
704-S	6800	704-W	11,200	15.00	11.40	57	2-5	20x20x60
804-S	7850	804-W	12,900	17.50	13.90	57	3-5	20x20x65
904-S	8900	904-W	14,600	20.00	16.40	57	3-5	20x20x65
1004-S	9950	1004-W	16,300	22.50	18.90	57	4-5	20x24x65
1104-S	11,000	1104-W	18,000	25.00	18.90	57	4-5	20x24x65
1204-S	12,000	1204-W	19,650	27.50	21.40	57	5-5	20x24x70
1304-S	13,000	1304-W	21,300	30.00	21.40	57	5-5	24x24x70
844-S	8480	844-W	13,990	20.85	15.35	58	3-5	20x20x60
944-S	9605	944-W	15,850	23.60	18.10	58	3-5	20x20x65
1044-S	10,730	1044-W	17,700	26.35	20.85	58	4-5	20x20x70
1144-S	11,855	1144-W	19,550	29.10	20.85	58	4-5	20x24x70
1244-S	12,980	1244-W	21,400	31.85	23.60	58	4-5	24x24x70
1344-S	14,105	1344-W	23,275	34.60	23.60	58	4-5	24x24x75
1444-S	15,230	1444-W	25,125	37.35	23.60	58	5-5	24x24x75
1544-S	16,225	1544-W	26,770	40.10	23.60	58	5-5	28x28x75
1644-S	17,125	1644-W	28.250	42.85	23.60	58	5-5	28x28x80

The Wickes Boiler Co.

(Established 1856)

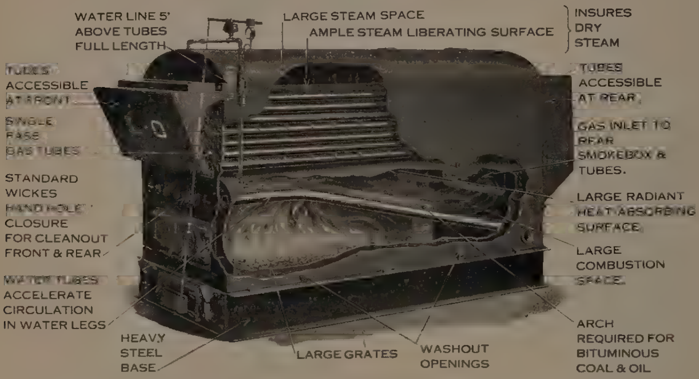
HEATING BOILER DIVISION

Saginaw, Mich.

Representatives in Principal Cities

WICKES "L-O" HEATING BOILERS

Exclusive License under C. W. Oberts Patent


WATER LINE 5' ABOVE TUBES FULL LENGTH
LARGE STEAM SPACE
AMPLE STEAM LIBERATING SURFACE
INSURES DRY STEAM
TUBES ACCESSIBLE AT FRONT
SINGLE PASS GAS TUBES
STANDARD WICKES HAND HOLE CLOSURE FOR CLEANOUT FRONT & REAR
WATER TUBES ACCELERATE CIRCULATION IN WATER LEGS
HEAVY STEEL BASE
LARGE GRATES
WASHOUT OPENINGS
TUBES ACCESSIBLE AT REAR
GAS INLET TO REAR SMOKEBOX & TUBES.
LARGE RADIANT HEAT ABSORBING SURFACE
LARGE COMBUSTION SPACE
ARCH REQUIRED FOR BITUMINOUS COAL & OIL

Wickes "L-O" Boilers provide a maximum evaporative power with a minimum of space occupied.

Sizes of Wickes Standard "L-O" Boilers for Steam Heating

(For Hot Water Radiation Multiply Steam Capacity by 1.60)

Boiler No.	Normal Operating Capacity, Sq. Ft. Radiation		General Proportions					Boiler Dimensions							Pipe Openings, In.		Lagging (Approx.), Sq. Ft.	Weight, Boiler, Steel Base, Grates, Fire Brick, Etc. (Approx.), Lb.
									Height In.			Length Ft.						
	Coal	Oil	Standard Grate Area, Sq. Ft.	Furnace Volume, Cu. Ft.	Heating Surface, Sq. Ft.	Steam Space, Cu. Ft.	Water Content, Cu. Ft.	Width, In.	Boiler Shell	Boiler and Standard Base	Water Line	Boiler Shell	Smoke Boxes	Boiler and Rear Boxes	Steam Outlet	Return (Each Side)		
LO-15	3200	4000	12	38	221	17	42	44	59	71	59	6	1¼	7¼	6	3	80	5995
LO-16	4000	5000	13½	45	253	20	48	44	59	71	59	7	1¼	8¼	6	3	95	6705
LO-17	4800	6000	15¾	53	318	26	61	50	64	79	66	7	1¼	8¼	6	3	105	8035
LO-18	5600	7000	17½	61	362	29	69	50	64	79	66	8	1¼	9¼	6	4	120	8650
LO-19	6400	8000	19¼	61	412	29	67	50	64	79	66	8	1¼	9¼	6	4	120	8980
LO-110	7200	9000	22	84	460	37	75	56	71	86	72	8	1½	9½	6	4	130	10180
LO-111	8000	10000	24	96	516	41	84	56	71	86	72	9	1½	10½	6	4	150	11855
LO-112	9600	12000	26	108	603	46	91	56	71	86	72	10	1½	11½	8	4	170	12035
LO-113	11200	14000	29¼	108	657	50	102	62	76	91	76	9	1½	10½	8	5	180	14500
LO-114	12800	16000	31½	122	765	56	109	62	76	91	76	10	1½	11½	8	5	185	14905
LO-115	14400	18000	33¾	135	840	62	119	62	76	91	76	11	1½	12½	8	5	200	15875
LO-116	16000	20000	35	158	948	74	130	68	79	97	81	11	1¾	12¾	8	5	210	17655
LO-117	20000	25000	37½	174	1187	81	133	68	82	100	84	12	1¾	13¾	8	5	235	19760
LO-118	24000	30000	42½	183	1350	81	165	68	88	106	90	12	1¾	13¾	8	6	250	21350
LO-119	28000	35000	44	231	1544	101	194	74	91	109	92	13	2	15	8	6	280	23700
LO-120	32000	40000	49½	250	1775	109	232	74	95	113	96	14	2	16	8	6	310	26030
LO-121	36000	45000	52¼	270	2088	117	265	74	99	117	100	15	2	17	10	7	340	28495
LO-122	40000	50000	54	273	2258	128	265	80	100	118	100	14	2	16	10	7	330	30890

The Vinco Company, Inc.

75 Vesey Street, **New York, N. Y.**

CABLE ADDRESS—Vincomp, New York

Vinco for Internal Cleansing of New, Remodeled and Old Heating Systems

Vinco Superfine Boiler Leak Seal

In 1½, 3, 5 and 10 lb. cans

What Vinco Is

VINCO (Latin, "I conquer"), a positively harmless insoluble powder cleanser for new, remodeled and old heating systems.

What Vinco Does

VINCO permanently removes all the oil, grease, scale and dirt from the internal surfaces and from the boiler water *without the labor of blowing boilers over the top.*

By this thorough cleansing Vinco stops foaming, priming, surging, incomplete circulation and poor radiation.

How Vinco Works

Each minute grain of VINCO powder absorbs several times its own weight of oil, rust and dirt. These large grains of absorbed impurities then settle and are blown through the bottom, according to directions on each can.

Vinco Specifications for New and Remodeled Steam and Vapor Systems

Cleaning the System—Upon completion of the installation, the contractor shall clean the system by the VINCO method to remove oil, grease, rust and dirt from the boiler using,*........lb. of VINCO, in exact accordance with manufacturer's directions.

This compound must remain in the boiler for 36 actual steaming hours, which corresponds to six or seven days average operation. At the end of this period, boiler must be thoroughly drained and flushed before refilling with clean water.

---

*In writing specification, insert in this space number of pounds of VINCO to be used in accordance with the following schedule. For systems having:

Up to	350	sq. ft.	of	*radiation	3	lb.
351 “	600	“	“	“	5	“
601 “	1100	“	“	“	8	“
1101 “	1400	“	“	“	10	“
1401 “	1800	“	“	“	13	“
1801 “	2100	“	“	“	15	“
2101 “	2700	“	“	“	18	“
2701 “	3100	“	“	“	20	“
3101 “	3700	“	“	“	23	“
3701 “	4200	“	“	“	26	“
4201 “	4600	“	“	“	28	“
4601 “	5000	“	“	“	30	“

Above 5000 sq. ft. use an additional pound of VINCO for each additional 300 sq. ft. of radiation.

---

*In determining amount of VINCO to be used all radiation may be taken at actual rating.

Vinco Specifications for Hot Water Systems

Cleaning the System—Upon completion of the installation, the contractor shall clean the system by the VINCO method using **...........lb. of VINCO in exact accordance with manufacturer's special directions for hot water systems, given on their cans.

**Only one half above quantities required for hot water systems.

Vinco for Old Systems

Annual cleaning of the old heating system adds years of life to the boiler, prevents rust deterioration and saves much fuel and fire attendance.

For old systems use only one half quantities given in specification table.

Our Free "Certified Chemically Correct" Laboratory Service—Send for Booklet

Explaining this service which saves needless piping changes, guesswork and dispute in puzzling water line problems.

Our Three-fold Guarantee

1. VINCO contains no potash, lye, soda of any kind, oil, acid, or other harmful ingredients.
2. VINCO meets every performance claim. Purchase price is refunded if results are not entirely satisfactory when VINCO has been used according to directions.
3. Your time, money and comfort are further safeguarded by our free laboratory service.

Vinco Distributors

VINCO is sold through leading boiler manufacturers and jobbers. It is never sold under any other name or in bulk. VINCO is put up only in 1½, 3, 5 and 10 lb. lithographed cans like illustration.

Patents are pending upon the product and method of application. Unlawful imitation is subject to prosecution.

Vinco Superfine Liquid Boiler Seal

A new and better leak seal. It makes speedy and permanent repairs of all boiler and heating system leaks.

It is fine to tighten up new jobs. The directions are simple to follow.

Quantities

Steam and Vapor Systems

Use 1 quart VINCO Liquid Boiler Seal to each 6 sq. ft. *grate* area.

Hot Water Systems

Use 2 quarts VINCO Liquid Boiler Seal to each 6 sq. ft. *grate* area.

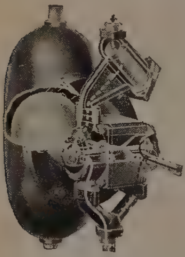
McDonnell & Miller
Boiler Feeders

"Doing one thing well"

General Offices: Wrigley Bldg., Chicago

Grand Central Terminal, New York

PRODUCTS—McDonnell & Miller No. 28 Self-Cleaning Duplex Boiler Feeders. McDonnell No. 29 Single Valve Self-Cleaning Boiler Feeders. McDonnell No. 30 Safety Feeders for small boilers.



For Medium and Large Boilers
The McDonnell & Miller No. 28 Self-Cleaning Duplex Feeder

Dependable Feed Water Regulation—McDonnell boiler feeders offer a simple and positive means of maintaining the boiler water line in low-pressure boilers. They protect the boiler from the costly repairs and shut downs that result when someone forgets the boiler water line.

McDonnell & Miller No. 28 Self-Cleaning Duplex Feeder—Used on low-pressure boilers requiring protection against flooding as well as low water. It prevents flooding by draining off surplus. It also maintains the boiler water line above the danger point by supplying make-up water as needed. The entire amount of feedwater for any boiler up to 20,000 ft. can be supplied by the McDonnell Self-Cleaning Duplex Feeder at 30 lb. differential water pressure.

Typical Specifications McDonnell & Miller No. 28 Self-Cleaning Duplex Boiler Feeders—Furnish and install on each (low-pressure heating) boiler, one McDonnell & Miller No. 28 Self-Cleaning Rotary Valve Duplex Boiler Feeder.

Rotary Valves to be adjustable to provide for a differential of from 1 to 5 in. between feed and overflow levels.

Installation to be made in accordance with diagrams and detailed instruction sheet furnished by the manufacturers.

McDonnell Single Valve Self-Cleaning Feeder No. 29—This type of feeder is adaptable for boilers that are operated constantly under a vacuum, or where steam is used in process work. It has the same general features and capacity as the self-cleaning duplex feeder, except that it has no overflow valve for draining off surplus.

For Process Boilers
The McDonnell & Miller No. 29 Single Valve Feeder

McDonnell No. 30 Safety Feeder—This feeder is designed especially for the smaller size boiler (up to 2000 ft.)—particularly oil-fired or gas-fired boilers in domestic use. It makes a most dependable and economical safety device for setting at the danger line. In this way it takes the place of the low-water cut-off and removes the disadvantage of a cut-off—the stopping of the burner with attendant danger of freezing the system. Its simplified construction makes possible a compact unit that is inexpensive to install and troublefree in operation.

For Small Boilers
The McDonnell & Miller No. 30 Safety Feeder

Typical Specifications McDonnell No. 30 Safety Feeder—Furnish and install on each (low-pressure heating) boiler, one McDonnell No. 30 Safety Feeder.

Installation to be made in accordance with diagrams and detailed instruction sheet furnished by the manufacturers.

Service and Information—The Engineering Department of McDonnell & Miller offers prompt advisory service to architects, engineers, contractors and boiler owners, regarding special problems. Descriptive literature giving further details of McDonnell & Miller Boiler Feeders, will be sent on request.

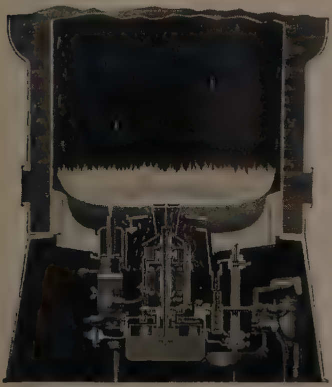
Automatic Burner Corporation

312 North May Street, **Chicago, Ill.**

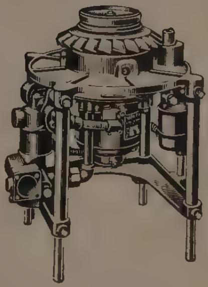
The Automatic Burner Corporation is a pioneer in the development and manufacture of the home rotary, in the ashpit type of oil burner. This principle—believed to be the simplest and most efficient for domestic oil burning—was developed in 1920.

In one of the industry's best equipped laboratories, thousands of dollars have been spent to perfect ABC Type E and its low priced companion—ABC Type H.

The Department of Engineering Research, University of Michigan, made some efficiency tests on June 15, 1928, with ABC installed in a DuBrie warm air furnace. ABC developed the high overall efficiency of 84.44 per cent.



Cross section of ABC Type in a round boiler



ABC Type H

ABC Type H—that duplicates the higher priced Type E in efficiency—is the burner for every man. The installed price is well within range of the low salaried man's purchasing power.

Simple, rigidly built and economical to operate, ABC Type H is guaranteed to satisfy the man who must count his dollars.

Write for
"OIL HEAT" for
The Architect and Engineer—
An authoritative book on Oil Burning.

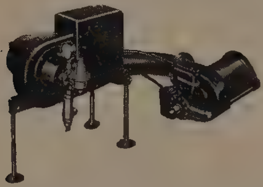
	ABC TYPE E	ABC TYPE H
Maximum Steam Radiation	3000	800
Price	\$500 to \$1000	\$350 to \$600

Electrol Incorporated

New York
227 East 45th Street

St. Louis, Mo.
170 Dorcas Street

Manufacturers of Electrol All-Electric Automatic Oil Burner



The Electrol Oil Burner is all-electric and fully automatic, combining mechanical fuel atomization and continuous electric ignition.

Suitable for all automatic applications.

Listed as standard by the Underwriters' Laboratories, Inc. Member, Oil Heating Institute.

PRINCIPAL FEATURES

Mechanical draft supplied by a Sirocco fan on the motor shaft.

The exclusive shell-shaped air receiver produces a rotary movement of the air, giving a ball-shaped flame, secured only with Electrol, that is extremely quiet and of high efficiency.

Listed to burn oil fuel not heavier than 28 gravity (A. O. B. A. Spec. No. 3), also Diesel oil (Pacific Coast) not heavier than 25 deg. A. P. I. when viscosity is not more than 54 seconds (Saybolt-Universal at 100 deg. fahr).

One pump directly connected to the motor shaft serves the double purpose of pumping oil from supply tank and maintaining the proper pressure for atomization. It is of the rotary gear type, having one driven gear and one idling gear-self-sealing. No stuffing box, auxiliary pump or motor is required.

The Ball shaped flame an exclusive Electrol feature, insures quiet operation and exceptionally high over-all efficiency.

Mechanical atomization is accomplished by forcing the oil under pressure through a specially designed nozzle. The nozzle on the Electrol is the only part that varies according to heating requirements. It is simple. It has no moving parts. Nothing to get out of order.

The atomized oil is mixed with the correct amount of air for proper combustion and ignited by an electric arc. In the Electrol burner ignition is continuous while oil is being pumped. In order to supply a heavy duty spark which is truly an arc, a transformer of sufficiently rugged construction to prevent overheating and breakdown of insulation is used.

Electrol automatic burners are manufactured in three sizes. The Model TJ, the Model TU, and the Model TD.

Motor Sizes: Model TJ —⅙ hp. Model TU—⅙ hp. Model TD—⅓ hp.

SAFETY

The safety system in the Electrol known as the Electrol Master Control was designed, and is used exclusively for Electrol. Should any abnormal condition occur this control immediately shuts down the burner and places it in a non-operating condition.

Dimensions and Capacities of Electrol Burners

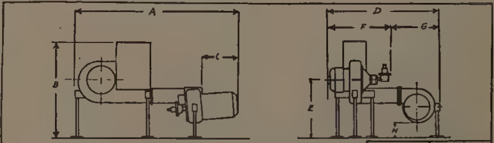
Range: Square Feet of Actual C. I. Radiators

Model	Steam Heat	Hot Water
TJ	200– 800	350–1300
TU	600–3000	1000–5000
TD	2000–5000	3500–8750

These ranges include piping and risers.

Ranges for vapor jobs fall in between the steam and hot water capacities and vary according to the degree of vacuum under which the system is operating.

Flame adjustments are made at the time of installation to meet requirements of boiler or furnace.



										Minimum	Maximum
Model	A	B	C	D	E	F	G	H	Motor	Gallons Per Hour	
Model TJ	26¼	17¾	5½"	21⅜	11¾"	16"	5⅜"	1⅛"	⅙ HP	1 Gallon	2½ Gallon
Model TU	42⅛	25⅜	8¾"	29⅛"	15⅜	16⅜"	12¾"	4⅛"	⅙ HP	2 Gallon	9 Gallon
Model TD	42⅛	25¾"	8¾"	32¼	18"	19½"	12¾"	6¾"	⅙ ¼ HP	9 Gallon	18 Gallon

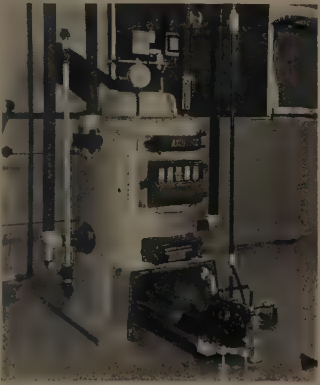
Oil Heat
for
every purse
and
purpose

Hardinge Brothers, Inc.

Manufacturers and Engineers
Main Office and Factory
4149 Ravenswood Avenue **Chicago, Ill.**

Distributors
in
Principal Cities
throughout the
United States

Manufacturers of HARDINGE Domestic and Industrial Oil Heating Equipment, Cataract Precision Lathes, Watchmakers and Opticians Tools and Supplies



Hardinge Brothers, Inc., manufacture a range of Oil Heating Equipment adaptable to Heating the Boiler with steam radiation loads of 300 to 25,000 sq. ft. per unit. It has been the aim of this organization not just to put another Oil Burner on the market, but to build into the HARDINGE the finest that material, workmanship, sound design, ample capital and more than one-third century of Precision experience could build. Architects, Heating Engineers and Contractors should feel free to call upon our Engineering Department for information of any kind on Oil Heating problems anywhere.

SEE OUR CATALOGUE IN SWEETS

Features:—

1—Mechanical Centrifugal Atomization without the use of fans, blowers, compressors or steam.

2—Applies heat at grate level, scrubbing insulating gases from water legs.

3—It is a self contained unit independent of the Combustion Chamber and not attached to the boiler in any way.

4—Burns automatically any commercial fuel oil available between 28 and 40 deg. A.P.I. Burns manually fuel oil between 18 and 40 deg. A.P.I.

5—Fuel Feeding Valve *self cleaning* in its operation.

6—Motor—Standard, horizontal, constant speed (1750 r.p.m.) motor operating under normal temperature conditions.

7—Listed as Standard by the *National Board of Fire Underwriters;* Tested and Approved by the New York City Board of Standards and Appeals.

8—Tested over a period of ten years by the ultimate judge of Oil Heat—the User Public who also approve.

Ratings **HARDINGE ATOMIZER-SIZES** **Ratings**

"FROM BUNGALOW TO SKYSCRAPER"

Atomizers Diam. Inches	Capacity in Sq. Ft. Steam Load	Motor H. P.
3	500	¼
3½	800	¼
4	1200	¼
4½	2000	¼
5	3000	⅓
5½	3800	⅓
6	4800	½
6½	5500	¾
7	6500	¾
8	10,000	1
9	15,000	1½
10	25,000	1½

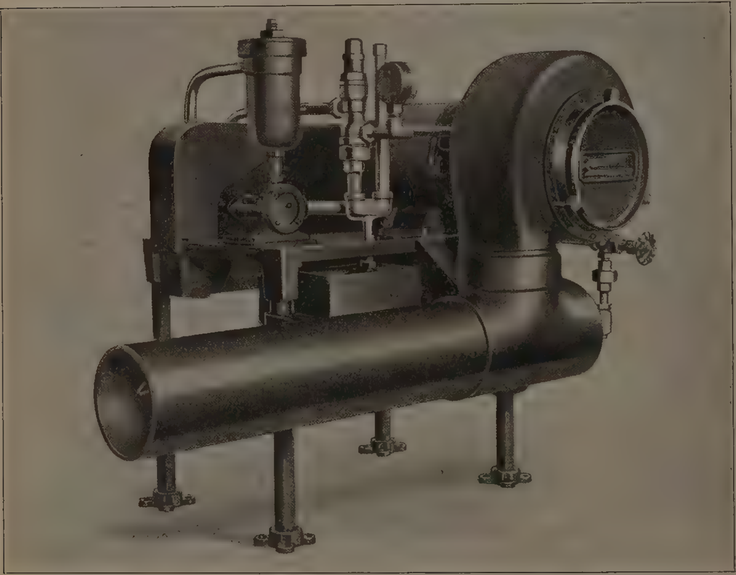
May Oil Burner Corporation

Factory and General Offices

Baltimore, Md.

Chicago Office
PURE OIL BUILDING
35 EAST WACKER DRIVE

New York Office
331 MADISON AVENUE



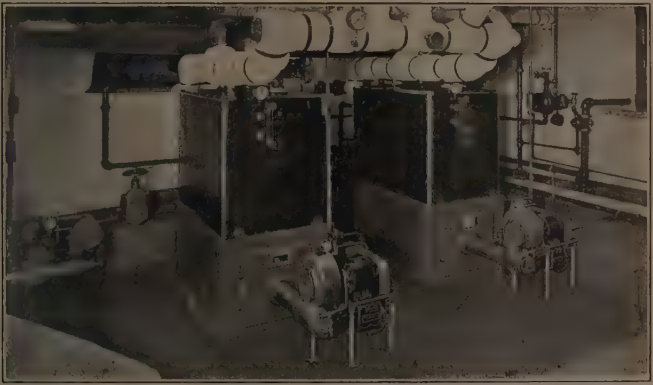
No radical changes to the boiler are necessary to permit the installation of a **Quiet MAY Automatic Oil Burner.**

The grates are removed and the combustion chamber of the boiler is lined with refractory material resulting in a combustion chamber in size and shape best suited to the heating load imposed upon the boiler.

When the installation is made the burner is equipped with an atomizer which delivers the proper amount of oil, in a spray, properly adapted to the size and shape of the combustion chamber.

The Quiet MAY is operated and ignited by electricity. No gas is employed. No part is inside the furnace or boiler so that in the event cleaning or adjusting is necessary each part is readily accessible.

Quiet MAY *Automatic* Oil Burner



THE Quiet MAY Automatic Oil Burner is a fully automatic oil burner, suitable for either domestic or commercial operation, in steam, hot water, vapor or warm air heating plants.

(1) Mechanical draft pressure atomizing burner. A. C. or D. C. motor drive. Intermittent operation. Completely automatic or manual control.

(2) Listed to burn 28 gravity oil (A. O. B. A. Spec. No. 3) or 25 gravity Pacific Coast Diesel oil.

(3) Oil is brought from storage tank by suction pump on burner which delivers it under pressure to the atomizer.

(4) Atomization is by specially designed mechanical pressure atomizer.

(5) Ignition by electric spark.

(6) Flame can be adjusted as to size and shape to meet requirements of boiler or furnace.

(7) Only changes required are removal of grates, and lining of combustion chamber with fire brick.

(8) Made in five sizes—for domestic and commercial installations. Adaptable to small homes and to large apartment buildings.

(9) Motor sizes: Type A—⅛ hp. Type M—⅙ hp. Type L—¼ hp. Type C—½ hp. Type R—1½ hp.

CAPACITIES

	Type "A"	Type "M"	Type "L"	Type "C"	Type "R"
Steam	600 sq. ft.	900 sq. ft.	2400 sq. ft.	8400 sq. ft.	16000 sq. ft.
Hot Water	1000 sq. ft.	1400 sq. ft.	4000 sq. ft.	14000 sq. ft.	24000 sq. ft.

Petroleum Heat & Power Company

PETRO

"MAKERS OF OIL BURNERS SINCE 1903"

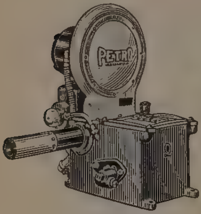
General Sales Offices: **Stamford, Conn.**

NoKol OIL HEAT

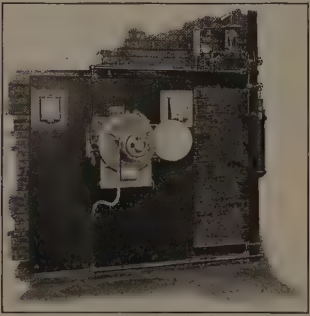
Factories	Branches		Subsidiaries
Stamford, Conn.	New York	Boston	Boston Harbor Oil Co.
Chicago, Ill.	Baltimore	Providence	East Coast Fuel Oil Co.
San Francisco, Calif.	Washington	Stamford	Fess System Co. of Calif.
	San Francisco	Los Angeles	

OIL BURNER MANUFACTURERS — **A NATIONAL ORGANIZATION** Dealers and Distributors in All Principal Cities — **FUEL OIL DISTRIBUTORS**

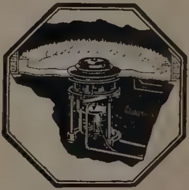
THE Petroleum Heat & Power Company manufactures the PetrO and NoKol lines of oil burners—two of the oldest and best known makes in the world. In the quarter century devoted to the specialized study of the oil burner business, this organization has developed a complete oil burner SERVICE that is now made available throughout the country through its widespread sales organization. Architects, Engineers and Heating Contractors are urged to consult its representatives on all their oil burner installation problems.



PetrO Model "LDO"
1,000 Sq. Ft. Steam



"New Fess" Industrial Burner



NoKol Model "R"
1,300 Sq. Ft. Steam

The Petroleum Heat & Power Company's Products Include the Following:

PetrO Automatic Line	Industrial Burner Line	NoKol Automatic Line
Six Sizes	**4 Designs**	**4 Designs**
1 to 52 gals. per hr.	10 to 130 gals. per hr.	½ to 35 gals. per hr.
Full Automatic Controls	Automatic Controls	Full Automatic Controls
Spark and Gas Ignition	Semi-Automatic Controls	Gas Ignition
#4 Oils, A. O. B. A. Spec.	Manual Controls	Full Spark Ignition
Full Spark Ignition	#6 Oils, A. O. B. A. Spec.	#1 to #3 Oils, A. O. B. A. Spec.
#3 Oils A. O. B. A. Spec.		

We Make Every Type of Burner — For Every Type of Boiler — For Every Type of Building

A Symbol of Service

A Symbol of Service

THE PETROLEUM HEAT & POWER COMPANY IS A GREAT OIL COMPANY

Winslow Boiler & Engineering Co.

Builders of* Kleen-Heet *Oil Burners

CHICAGO
844 Rush St.

NEW YORK
11 W. 42nd St.

GALESBURG
Illinois

Challenger

Ignition: Pencil gas flame metered to 1,000 cu. ft. per month.

Air Supply: 1/30 hp. meter fan unit with precision air damper assures uniform air for any given oil rate.

Oil Feed: Uses Monroe, Teesdale, Cook or any approved automatic electric oil pump or may be direct-connection to 270 gallon basement tank.

Controls: Fully automatic Minneapolis-Honeywell thermostat and standard hydro or pressurestat.

Mechanism: Simple—1/30 hp. rubber mounted motor fan unit.

Safety: Listed as standard by the Underwriters' Laboratories.

Fuel: No. 1 A. O. B. S.

Appearance: Neat, Compact, Duco finish.

Quietness: Must see and listen to grasp true quietness of this machine.

Capacity: Up to 650 sq. ft. of steam load.

Now the Improved Challenger*—for average-size homes· simple, silent. automatic— at a new low-cost level.*

De Luxe 800

Ignition: Webster transformer controller by Minneaplis-Honeywell Protectostat.

Air Supply: 1/6 hp. Century motor driven sirocco fan with peripheral type rotating air damper.

Oil Feed: Special Viking Kleen-Heet oil pump-vacuum side has by-pass to stuffing box taking load off of motor and assuring non-leaking packing.

Controls: Fully automatic Minneapolis-Honeywell thermostat and standard hydro or pressurestat.

Mechanism: Simple—1/6 hp. motor fan pump unit.

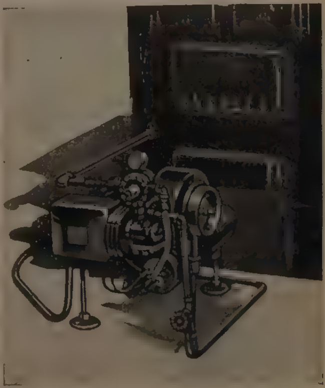
Safety: Listed as standard by the Underwriters' Laboratories.

Fuel: No. 3 A. O. B. S.

Appearance: Neat, Compact, Duco finish.

Quietness: Must see and listen to grasp true quietness of this machine.

Capacity: Up to 6,800 sq. ft. of steam load.



Kleen-Heet *"800 Series" model—the acknowledged de luxe in oil heat, regardless of price—for all heavy duty, fully automatic heating.*

Williams Oil-O-Matic Heating Corporation

Manufacturers of Automatic Oil Burners

Bloomington, Illinois

NEW YORK, N. Y., 420 Lexington Avenue
CHICAGO, ILL., 185 N. Michigan Avenue

Authorized Dealers and Factory Trained Installation and Service Organization in all Principal Cities of the United States and Canada, also in 75 other large Cities throughout the Civilized World.

Williams Oil-O-Matic Heating is 10 Years and 90,000 Installations *Beyond Experiment*

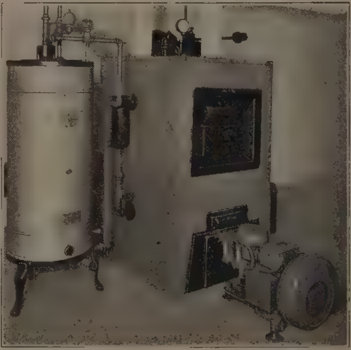
Williams Oil-O-Matic heating for domestic or commercial installations can be safely recommended by heating engineers, contractors and architects. Today more than 90,000 Williams Oil-O-Matic installations in every state and province, from Alaska to Australia, are automatically and satisfactorily maintaining predetermined temperature in any weather.

In many instances Oil-O-Matic fuel costs are no higher than for hard coal—thousands of enthusiastic owners even claim savings—and the work of hand firing coal, removing ashes and cleaning dust and smudge is eliminated.

Advantages—To burn oil efficiently: (1) Oil must be atomized, not vaporized. (2) Oil must be mixed with a fixed minimum quantity of air. (3) Oil must burn in suspension. (4) Oil must burn in the presence of a refractory material.

Oil-O-Matic operation complies strictly with these well-known natural laws governing the combustion of liquid fuel, as outlined in Dyson's "Naval Engineering," and the reference works of Harding and Willard Kent, and other like authorities.

The patented exclusive Oil-O-Matic metering pump permits burning cheap 28 to 30 deg. Baume fuel oil, but will handle equally well, all lighter furnace oils. Change in fuel does not necessitate a change in burner adjustment. Oil-O-Matic method of atomization eliminates all high pressure and needle valve atomization. Oil-O-Matic air control permits use of a low velocity air blast, adjustable over a wide range of service, to meet the requirements of all existing types of heating plants. Continuous gas pilot is not used. Automatic intermittent spark ignition operates for about ten seconds only, when burner starts. Room thermostat controls on and off operation of burner. Controls safeguard heating plant temperatures and pressures. Wear is automatically adjusted. Fuel pump may be had with oil level switch or stack safety control.



Domestic Hot Water Supply—The mechanically fired, automatically controlled heating plant has permitted the development of a practical and inexpensive, fully automatic domestic hot water supply system, which provides an inexhaustible supply of hot water at a very low cost.

Complete description will be found in "Oil Heating—What It Means to the Architect." (See Catalogues).

Operating Efficiency—Combustion efficiency in domestic heating systems, the equal of industrial power plant operation, is obtainable with Oil-O-Matic. A test run by A. H. Hansen, Engineer, Metropolitan Utilities, Omaha, reads:

> "Burner was tested for fuel consumption, gas consumption for ignition, and flue gases were analyzed for combustion efficiency.
>
> "Atmosphere was 29 deg. fahr., house was maintained at 72 deg. fahr. Burner operated 22 per cent of the time. Flue gas analysis—CO_2 12.2 per cent; O, 4.4 per cent; CO, none. Flue and combustion chamber was entirely free of soot."

Details of this and many other tests on request.

WILLIAMS OIL-O-MATIC HEATING

More Than 90,000 Satisfactory Installations

Models—Oil-O-Matic Model J Type 1200 is designed for steam heating system serving 1500 sq. ft. direct steam radiation or less; hot water system serving 2500 sq. ft. direct hot water radiation or less; hot air furnace of 36 in. grate diameter or less.

Model J Type 1800 is designed for heating systems larger than the model 1200. Will handle up to maximum of 4000 sq. ft. direct steam radiation; 6400 sq. ft. direct hot water radiation, or hot air furnace with maximum grate area of 14 sq. ft.

New Oil-O-Matic Junior

The recently announced Oil-O-Matic Model JR provide the most satisfactory heating for small residences and buildings. At lower first cost and operating cost it provides typical Williams satisfaction for 750 sq. ft. direct steam radiation. It will easily handle 1250 sq. ft. direct hot water radiation or a hot air furnace with a 30-in. grate. Oil-O-Matic JR has a maximum oil capacity of 3 gallons per hour as compared to the 5-gallon maximum of the Model J 1200.

All Oil-O-Matic models may be installed in any type furnace or small boiler.

All Oil-O-Matic oil burners operate on standard 110- and 220-volt 60 cycle A.C. or D.C. current as specified by you.

Installation—Grates and ash pit door are removed. Ash pit door is closed with fire brick after Oil-O-Matic draft pipe is inserted, as illustrated.

Williams Oil-O-Matic Model JR

Contractor should also figure oil storage, consisting of 60-gallon tank, or other capacity, installed to comply with local ordinance; to be installed in basement; or a 1000 or 2000-gallon outside tank, buried not less than 3 ft. below grade and not more than 100 ft. from Oil-O-Matic; bottom of tank to be not more than 12 ft. below suction pump on burner.

Installation must be made in accordance with Fire Underwriters' rules, city ordinances and fire department regulations.

Operation—Owner need only set room thermostat to desired temperature, turn on electricity—and forget all heating problems. Factory trained Williams service men are available most everywhere.

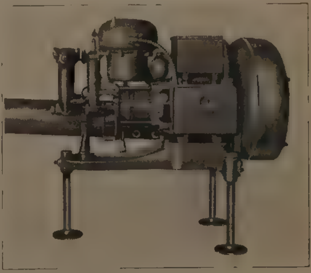
Range of Service—Oil-O-Matic oil burners are heating every type of building:

Houses
Banks
Stores
Hotels
Garages
Schools
Theaters
Hospitals
Churches
Clubs
Apartments

Members of the engineering and architectural professions are offered authoritative and practical counsel on installations and specifications. Look under "Oil Burners" in local classified telephone directory or wire or write to our New York, Chicago or Bloomington offices for prompt information.

Catalogues

"Oil Heating—What It Means to the Architect."
"Oil Heating at Its Best."



Williams Oil-O-Matic Model J

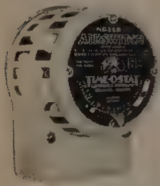
Time-O-Stat Controls Company

Elkhart, Indiana

Manufacturers of automatic controls for Gas Burners; Oil Burners; Coal Burners; Electric Refrigerators; Mechanical Stokers; Furnace Fans; Industrial Ovens; Ice Machines; Unit Heaters; Water Heaters.

Also manufacturers of Sign Flashers; Mercury Switches; Electric Heaters; and Corrugated Metal Bellows

The Time-O-Stat Series 500 Temperature Regulator has a snap action contact blade, which prevents arcing and pitting. Its mechanical simplicity offers to users of all types of heating systems a dependable means of automatic temperature control. This control operates on low voltage and is available either with or without an eight day Seth Thomas clock for time control. It is furnished in either statuary bronze or chromium finish.



The 149R Airswitch is a room temperature control primarily designed for industrial rather than domestic installations. It is used in the control of heating equipment installed in garages, factories, warehouses, and similar buildings where wide range of operation and sturdy construction are more important than extreme sensitivity. It will control temperatures between minus 10 to plus 130 deg. fahr., and will maintain the temperature set on the scale within a variation of 5 deg. The 149R Airswitch is a two-wire high-voltage control and is so constructed that it will resist corrosion or injury and will stand up under hard usage.

For operation on high voltage, our 135 and 136 Thermoswitches are recommended. The principle used in operating these thermoswitches is the expansion and contraction of the bimetallic element on which the mercury tube is mounted. The 137 and 138 are identical with the 135 and 136, except that they are three-wire controls for use on low voltage systems. The 136 and 138 are clock Thermoswitches.

The 64 Thermoswitch is a high capacity room temperature control, having an electrical rating of 10 Amp., 110V.; 5 Amp., 220V. This instrument will maintain temperature within a variation of 2 deg., and is carefully adjusted at the factory for 70 deg. fahr. The No. 64 is sturdily constructed and will give years of dependable service. Moving parts have been reduced to a minimum. A knurled nut on the right-hand side of the case may be turned to set the instrument for temperature. The mercury switch is controlled by the expansion and contraction of a metal bellows.

The Aquaswitch is a very efficient temperature control for hot water systems. Its outstanding feature is that it may be clamped on the hot water riser near the boiler and reacts to temperature change by conduction through its back which is in contact with the hot pipe. There is no necessity for tapping the boiler or draining the system when this control is installed. The change of temperature causes expansion or contraction of a bimetal spiral which, in turn, rotates the mercury tube which is mounted on it, thus making and breaking the circuit. The Aquaswitch may be mounted on either vertical or horizontal risers. This instrument is arranged for high voltage. For low voltage control systems the three-wire 56B is used.

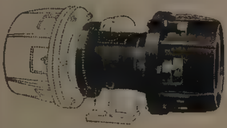
As only a few of the complete line of instruments we manufacture can be listed in this space, we would be very glad to have you write for further information on our complete line of controls for use on the diversified line of equipment listed at top of page.

AMERICAN DISTRICT STEAM COMPANY

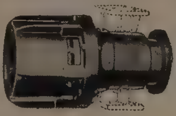
GENERAL OFFICES AND WORKS
NORTH TONAWANDA, N.Y.
50 YEARS IN BUSINESS
Branches and Agents in Principal Cities

ADSCO SLIP TYPE Expansion Joint

Dotted lines illustrate some of the combinations of ADSCO Expansion Joints

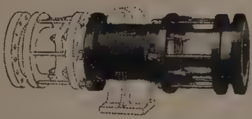


ADSCO Externally-Guided Expansion Joints for 4, 6, 8, 10 and 12 in. traverse, 125 and 250 lb. pressure.



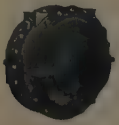
ADSCO Duplex-Sleeve Guided Expansion Joint for pressures up to 400 lb. and temperatures to 750 deg. fahr. Air-cooled slip eliminates excessive packing and maintenance costs and assures a tight joint.

ADSCO Semi-Guided Expansion Joint for 4, 6, 8, 10 and 12 in. traverse, 125 and 250 lb. pressure.



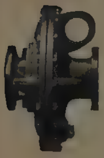
ADSCO Semi-Guided Expansion Joint with tie rods for 4, 6, 8, 10 and 12 in. traverse, 125 and 250 lb. pressure.

ADSCO Variators (Packless Expansion Joints) Expansion absorbed by corrugated diaphragms



Model "O" Double Variator

For pressure up to 50 lb. Total traverse 2¾ in. Takes care of 120 ft. of pipe at 50 lb. pressure. Service outlet and anchor plates.



Model "O" Single Variator

For pressure up to 50 lb. Total traverse 1⅜ in. Takes care of 60 ft. of pipe at 50 lb. pressure. Has service outlet, anchor and drip.

Model "P" Double Variator

Smaller diameter and lighter weight than the Model "O". Made in double type only. For pressure up to 125 lb. Total traverse 2 in. Not furnished with service outlets or anchor.

Send for **"Blue Book on Expansion"** which describes complete line of **ADSCO Expansion Joints** for every pipe expansion requirement.

ADSCO Multiple Diaphragm Variator

For High Pressures and High Temperatures

With the exception of new metals in diaphragm and other parts, the design of the new **ADSCO** Variator for high pressures (to 400 lb.) and high temperatures (to 750 deg. fahr.) is substantially the same as the **ADSCO** Low Pressure Variator, thousands of which have been installed during the past 20 years, with less than 1/10 of 1 per cent ever having required attention.

Each diaphragm of this new Variator accommodates a full ¾ in. movement, and can be assembled in series to provide for any expansion requirement up to 4½ in. per unit. Per inch of traverse, they cost little, if any, more than much less satisfactory equipment. Send for new bulletin which illustrates and describes this new Variator in detail.

E. B. Badger & Sons Co.

75 Pitts Street, **Boston, Mass.**

Offices and Agencies
In Nineteen Leading Cities

PRODUCTS—Corrugated Copper Expansion Joints; Pipe Bends; Chemical Apparatus; Copper and Sheet Metal Work; Copper Boilers.

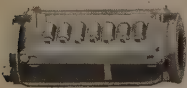
BADGER SELF-EQUALIZING EXPANSION JOINTS

Badger Expansion Joints distribute the expansion *uniformly* over the whole joint by means of cast iron or steel equalizing rings. These fit the corrugations, as shown, and prevent local concentration of the stress on any one corrugation. The tubes are made of the best deoxidized copper. No packing is used or needed. They will not leak.

Standard Badger Joints are built for pressures up to 200 lb. Single joints take care of expansions up to 3 in. at any one point. Double joints handle up to 6-in. expansions. Both flanged and welding types are made.

Low Pressure Joints—Single and Multiple Expansion—Especially suited to absorb vibration and shock and to provide a flexible connection between turbine or engine exhaust and the condenser. Guaranteed for pressures to 30 lb. Made with 1 to 5 corrugations. Fitted with flanges of low or standard pressure dimensions. Also made oval and rectangular to fit requirements.

Flanged Type, for Saturated Steam, Hot Water and Other Hot Liquids—For 4 and 5-In. Pipe—Made with 4 or 8 corrugations for 1 or 2 in. of expansion, respectively. Fitted with alignment bars. Made for low, standard or extra heavy pressure.



For 6-In. Pipe and Larger—Made with 2, 3, 4 or 5 corrugations for 1, 1½, 2 or 3 in. of expansion, respectively. Furnished with 125-lb. standard and 250-lb. extra heavy flanges. Sizes larger than 30 in. furnished on special order.

Also furnished in double units, including base plate, anchor and guides with or without service outlet.

For Superheated Steam—Similar to preceding type, except that a telescoping monel metal sleeve is fitted inside the joint to protect the copper from deterioration due to the superheat in the steam.

Number of corrugations and dimensions same as for joints for 6-in. pipe and larger.

FLANGED TYPES
Face to Face Dimensions in Inches

Size	Number of Corrugations				
	2	3	4	5	8
4, 5	....	....	12 7/16	....	19 7/16
6	12½	16	19	23	....
8	12½	16	19	23	....
10	12½	16	19	23	....
12	13	16½	19½	23½	....
14	13½	17	20	24	....
16	13½	17	20	24	....
18	14	17½	21	24½	....
20	15	18½	21½	25¼	....
22	15	18½	21½	25¼	....
24	15½	19	22	25¾	....
26	15½	19	22	25¾	....
28	15½	19	22	25¾	....
30	15½	19	22	25¾	....

Welding Type—Made for saturated steam and for superheated steam with monel metal sleeves. Open pipe nipples are homogeneously attached to the copper, with ends scarfed and ready for welding into pipe lines.

Single—For 3 and 4-in. pipe have 4 and 8 corrugations for 1 and 2 in. of expansion, respectively. For 5 to 20-in. pipe have 2, 3, 4 or 5 corrugations for 1, 1½, 2 or 3 in. of expansion, respectively.

Double—Similar to single type, except that two expansion joints are welded in tandem. Made with 4, 6, 8 or 10 corrugations for 2, 3, 4 and 6 in. of expansion, respectively. Also furnished as units including base plate, anchor and guides and with service connection if desired.

WELDING TYPES
Face to Face Dimensions in Inches

Size	Single Type					Double Type			
	No. of Corrugations					No. of Corrugations			
	2	3	4	5	8	4	6	8	10
3, 4	....	.....	36	.....	43	56 13/16	.....	70 13/16	.....
5, 6	35⅝	38 13/16	42	45 11/16	...	60⅜	66¾	73⅛	79½
8	35⅝	38 13/16	42	45 11/16	..	61	67⅜	73¾	80⅛
10, 12	35⅝	38 13/16	42	45 11/16	...	62	68⅜	74¾	81⅛
14, 16	35⅝	38 13/16	42	45 11/16	...	63 11/16	69 7/16	75 13/16	82 3/16
18, 20	35⅝	38 13/16	42	45 11/16	...	64⅛	70½	76⅞	83¼

American Blower Corporation

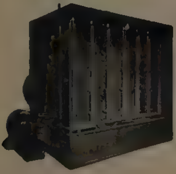
General Offices: **Detroit**

Works: Detroit, Mich.—Bond Hill, Cincinnati, Ohio

Branches and Sales Offices

City and Address	Telephone
Akron, Ohio, 225 W. Exchange Street	Main 6096
Atlanta, Ga., 614-615 Bona-Allen Bldg.	Walnut 5643
Baltimore, Md., 207-8 Munsey Bldg.	Plaza 3774
Birmingham, Ala., 1308 American Traders Bk. Bldg.	7-2383
Boston, Mass., 1003 Statler Bldg.	Liberty 8347-48
Buffalo, N. Y., White Bldg.	Seneca 2668
Charlotte, N. C., 220 Builders Bldg.	Jackson 122
Chattanooga, Tenn., 1104 James Bldg.	6-6657
Chicago, Ill., 228 N. La Salle Street	Central 1631-32
Cincinnati, Ohio, 905 Sycamore Street	Canal 8161-62
Cleveland, Ohio, 1302-3 Swetland Bldg.	Main 6846-47
Columbus, Ohio, 33 N. High Street	Main 3443
Dallas, Texas, 921 Mercantile Bk. Bldg.	X-5518
Davenport, Ia., 401 First Nat'l Bk. Bldg.	Dav. 4006
Denver, Colo., 1226 California Street	Main 5818
Detroit, Mich., 2539 Woodward, Hofman Bldg.	Cad. 8880-81
El Paso. Texas, P. O. Box 240	Main 2739
Export Dept., Rm. 1510, 30 Church Street, N. Y. C.,	Cortlandt 4856
Flint, Mich., 206 Sherman Bldg.	9-3310
Grand Rapids, Mich., 604 Bldg. & Loan Bldg.,	Citizens 41122
Hartford, Conn., Rm. 605, 252 Asylum Street	2-2027
Indianapolis, Ind., 819 Continental Bk. Bldg.,	Lincoln 6745
Kansas City, Mo., 310-312 Mutual Bldg.	Victor 5965
Los Angeles, Calif., 427 Union Ins. Bldg., 1008 W. Sixth St.,	FAber 3871
Louisville, Ky., 1119 Heyburn Bldg.	City 952
Milwaukee, Wis., 1418-19 Majestic Bldg.	Grand 1986
Minneapolis, Minn., 808 La Salle Avenue	Main 0034
Newark, N. J., 79-81 Ogden Street	Branch Brook 8540-41
New Orleans, La., Queen and Crescent Bldg.,	Main 5971
New York, N. Y., 50 Church Street	Cortlandt 1009
Oklahoma City, Okla., 1722 Petroleum Bldg.	2-1542
Omaha, Nebr., Peters Trust Bldg.	ATlantic 6548
Philadelphia, Pa., Otis Bldg., 112 South 16th Street	(Bell) Rittenhouse 6393-4
Pittsburgh, Pa., 801 First Nat'l. Bank Bldg.	Atlantic 3496-3497
Portland. Ore., 1002 Pacific Bldg.	BEacon 6197
Reading. Pa., 506 American Casualty Bldg.	37112
Rochester, N. Y., 907 Gas & Elec. Bldg., 89 East Avenue,	Stone 345-346
St. Louis, Mo., 1221 Boatmen's Bk. Bldg.	Garf. 1278
Salt Lake City, Utah. Dooly Bldg.	Wasatch 1680-1681
San Francisco, Calif., Rialto Bldg.	Sutter 1024-1025
Schenectady, N. Y., 331 State St., Imperial Bldg.	7503
Seattle, Wash., 605 Leary Bldg.	Eliott 0713
South Bend, Ind., 505 Pythian Bldg.	3-5455
Syracuse, N. Y., 1200 Hills Bldg.	3-0170
Tacoma, Wash., 1127 St. Paul Avenue	Main 3150
Toledo, Ohio, Rm. 302. 320 Ontario Street	Adams 6512
Youngstown, Ohio, 1008 Mahoning Bank Bldg.	4-3593
Washington, D. C., 934 Nat'l. Press Bldg.	Nat'l 4857

"Sirocco" Fans and Blowers for heating, ventilating, cooling, drying and mechanical draft.



"Sirocco" Air Washer—for purifying and humidifying air for dehumidifying and cooling.

Venturafin Unit Heater—one small unit is equal to 500 feet of direct radiation—occupies only one-fourth the space and has only one-tenth the weight.

"Sirocco" Utility Blower—a compact, durable ventilator for installation with ducts.

A. B. C. Air Filter—Dry plate constant effect air filter—a highly efficient device for collecting dust in public and industrial buildings of every type and description.

"Ventura" Disc Fan for operation under free air delivery conditions — a complete ventilation system in itself.

Descriptive folders on any subject of air handling —heating, ventilating and mechanical draft will be furnished free on request.

Bayley Blower Company

784 Greenbush Street **Branches in Principal Cities** Milwaukee, Wis.

BUILDERS OF HEATING, VENTILATING, COOLING, PURIFYING, HUMIDIFYING AND AIR WASHING EQUIPMENT; EXHAUST AND DRYING APPARATUS, MECHANICAL DRAFT AND BLAST, FANS AND BLOWERS OF ALL TYPES

BAYLEY PLEXIFORM FAN:

Used to supply air for heating systems or heating and ventilating systems for manufacturing and process industries, for drying systems, or for forced or induced draft systems for boiler plants.

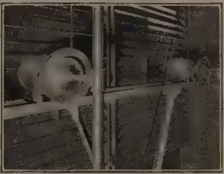
The Plexiform Fan is suitable for handling cool or warm air, as well as high or low temperature gases. It will deliver the maximum quantity of air in applications where medium or low pressure is required.

For applications where space is limited, or where economy of power is desirable, this fan is especially recommended.

The fan wheel, of distinct Bayley design, has great strength without excess weight. Due to its reinforced construction and equal distribution of stresses, vibration is reduced to a minimum. Crystallization of parts, so called, is thus avoided. Large and unobstructed inlets and outlets, and the absence of arbitrary air cut-offs, insure free and noiseless delivery of air.

Bayley Plexiform Fans are furnished in either single or double width wheel types of any required housing construction, and discharge positive sleeve or ball bearings as specified.

TURBO AIR WASHER AND HUMIDIFIER:



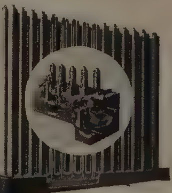
The Bayley Turbo Air Washer Showing Turbo Atomizer and Eliminator

The Bayley Air Washing System is offered for all public and industrial buildings, where a central system of air washing and humidifying is desired.

Competitive air washing and humidifying equipment requires frequent cleaning of the spray nozzles, as the particles of dirt in the recirculated water rapidly clogs the orifices.

The Turbo Atomizer used in the Bayley Washer, produces a steady, fine spray. Water at low pressure is delivered to the center of a rapidly revolving cone-shaped rotor provided with atomizing pins set in its periphery. This atomizer cannot clog, requires very little attention, and will operate successfully under low water pressure. The spray is uniform, and there are never any spaces in the Air Washer that are not completely filled with a fine mist. Bayley Turbo Air Washer and Conditioners may be used for washing, cooling, humidifying, or dehumidifying, as required.

CHINOOK HEATING SECTIONS:



The Chinook Section is used with fan type heating, ventilating, and drying systems. It circulates either high or low pressure steam by gravity or under a vacuum. The heater may also be used to circulate hot water for heating purposes, or cold water for cooling purposes.

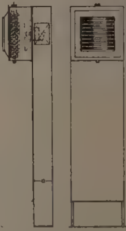
The Chinook base is of grey cast iron, having walls of sufficient thickness to withstand a working pressure of 175 lb. per sq. in. The casting is divided into two chambers by a horizontal partition. Steam enters the lower or steam chamber from which it rises through ⅜-in. wrought pipes, which are located within the 1¼-in. wrought pipes leading from the upper chamber. Thus the steam in the steam chamber passes up through the small pipes (which are open at the top) into the larger pipes, where condensation takes place, the water and air falling into the upper chamber and draining away through the return outlet. Each tube is evenly heated through its entire length, and air binding cannot occur. The Chinook is the only heater in which a leak can be repaired in the middle of the tank without breaking steam connections or taking down a single section.

Shipped assembled in smaller sizes, and knocked down in the larger units. May be installed in horizontal or vertical position.

BAYLEY TYPE EXHAUST FAN:

An exhaust unit for handling refuse from sawmills, planing mills, cotton gins, textile mills and wood working plants, designed for high efficiency at moderate speed. Its outstanding features are the blast wheel which is built up from an accurately machined and balanced center, insuring well balanced wheel and making replacement of accidentally broken blades a simple matter.

DISCFIN HEATERS:



Single Unit of the Supported Type with Air Connection from the Floor Line

Discfin Heaters are constructed along the lines original with the Bayley Blower Company, as described under Chinook Heating Sections.

The Discfin unit illustrated is particularly adapted to use in offices and entrances to buildings, as well as the main portions of industrial plants. It may be connected to the outside air, and thus will ventilate as well as heat the space in which it is installed.

The heaters are sturdy, efficient, easily installed, and occupy no valuable floor or wall space. They require no special structure to carry them, and they may be attached to walls or columns, suspended from the floor above, or from the heating main, as circumstances will permit.

It is not necessary when this heater is used, to recirculate air at room temperature. Air directly from out of doors may be led to the unit, thus making it a ventilating as well as a heating unit. The entire unit is tested to a working pressure of 80 lb.

The Bayley Blower Company offer in addition to the Discfin described, larger sizes of industrial unit heaters. The well-known B.t.u. Heater is popular in railroad roundhouses and shops. The I.C.U. Heater is also an industrial unit of somewhat lighter construction, which is adapted to use in industrial buildings of all sorts.

BAYLEY CHINOOKFIN HEATING SECTIONS:

The Chinookfin heater embodies the same successful principles of construction as the original Chinook, except that the radiating element is copper tubing, carrying extended copper-fin surfaces. The manner of attaching the fins so as to remain tight under all conditions and temperature changes is unique and very efficient.

Each pipe is separate, individual, and independent; expansion and contraction of any one pipe does not affect the others; no rigid connections, return bends, nipples, of elbows, to be racked out of shape by unequal expansion and contraction. This construction permits continuous and innumerable cycles of expansion and contraction without crystallization of materials and resulting damage.

The Bayley Chinookfin Heater is as safe for tempering coil service as for reheaters—a remarkable feature of this heater.

Write for Bulletin No. 29-C which describes it in detail.

The Buckeye Blower Company

Main Office and Factory
400 Dublin Avenue, **Columbus, Ohio**

Branch Sales and Service Offices

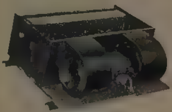
Atlanta, Ga.
Baltimore, Md.
Boston, Mass.
Buffalo, N. Y.
Chicago, Ill.
Cleveland, Ohio
Dallas, Texas
Denver, Colo.
Detroit, Mich.
Grand Rapids, Mich.
Harrisburg, Pa.
Hempstead, N. Y.
Indianapolis, Ind.
Kansas City, Mo.
Los Angeles, Calif.
Milwaukee, Wis.
Minneapolis, Minn.
Newark, N. J.
New York City
Philadelphia, Pa.
Pittsburgh, Pa.
Portland, Ore.
Richmond, Va.
St. Joseph, Mo.
St. Louis, Mo.
Salt Lake City, Utah
Seattle, Wash.
Syracuse, N. Y.
Youngstown, Ohio

IN CANADA: TORONTO, ONTARIO

Manufacturers of BUCKEYE Heating and Ventilating and Air Conditioning Apparatus

---

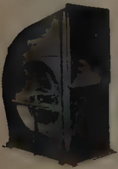
The Buckeye Heatovent has been developed for use in School Rooms and places where quiet running, temperature control, quick heating, and positive ventilation are requisites. This machine is equipped with the oval tube copper radiator which will not burst when frozen.



The Buckeye Thermovent has been developed for larger installations requiring from 2000 to 5000 c.f.m. as churches, auditoriums, garages. Horizontal type for ceiling hanging, vertical type for floor setting. Equipped with or without mixing dampers.

The Buckeye Giant Unit Heater was especially designed and developed for Airplane Hanger and large Industrial Building Heating. Capacities up to 20,000 c.f.m. and 2,000,000 B.t.u.

The Buckeye Thermofan is a propeller fan type of unit for smaller industrial work-rooms. Can be used for fresh air supply or recirculating jobs, equipped with or without ducts to floor.



Multiblade Fans for heating, ventilating, drying, dust removal and allied uses in all sizes up to 100,000 c.f.m. and up to 6 in. static pressure.

Ozonation and humidity treatment available for all unit applications. Engineering service available in all branch offices.

Buffalo Forge Company

"Air Engineers For Over Fifty Years"

450 Broadway, **Buffalo, N. Y.**

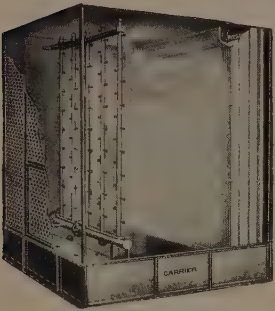
Sales Engineering Offices

Ammarillo, Texas	Ammarillo Bldg.	Minneapolis, Minn.	459 N.W. National Life Bldg.
Boston, Mass.	10 Milk Street	New York, N. Y.	39-41 Cortlandt Street
Chicago, Ill.	562 W. Washington Blvd.	Philadelphia, Pa.	1302 Land Title Bldg.
Cleveland, Ohio	368 Rockefeller Bldg.	Pittsburgh, Pa.	927 Union Trust Bldg.
Cincinnati, Ohio	604 Mercantile Library Bldg.	Portland, Ore.	355 Everett Street
Dallas, Texas	601 Construction Bldg.	San Francisco, Calif.	365 Tenth Street
Denver, Colo.	1621—17th Street	St. Louis, Mo.	906 Chemical Bldg.
Detroit, Mich.	2051 W. Lafayette Blvd.	Seattle, Wash.	303 Alaska Bldg.
Indianapolis, Ind.	State Life Bldg.	Washington, D. C.	418 Washington Loan Trust Bldg.
Los Angeles, Calif.	610 Pershing Square Bldg.		

Complete line manufactured in Canada by Canadian Blower & Forge Co., Ltd., Kitchener, Ontario

Manufacturers of Heating and Ventilating Equipment, including: Multiblade Fans, Pipe Coil Heaters, Unit Heaters, Carrier Air Washers, Exhaust Fans, Blowers, Dust Collectors, Disc Fans, Spray Nozzles, Mechanical Draft, Drying Equipment, Multistage Blowers and Exhausters

Complete descriptive literature sent on request



Air Washers

One-Piece eliminators and scrubbers that are easily assembled in a few minutes and give great cleaning effect. Spray nozzles prevented from clogging by tank-width screen. Original efficiency is maintained indefinitely by a few minutes flushing out each week.

Buffalo Niagara Conoidal

Fans handle large quantities of air at high efficiency under big overloads in industrial plants. Low speed and great capacity well suited to belt drive.

Buffalo Breezo Propellers

Fans are very successfully used for removing steam, odors or foul air in shops, mills and factories. Belted or direct motor driven types.

The New Silex Conoidal Ventilating Fan

An improved type of ventilating fan, designed from our experiments and experiences to reduce audible noise to a minimum. The housing is a "rolled-up evase stack," converting air velocity leaving the rotor into static pressure. The cone is carried out beyond casing in order to get best conversion efficiency, and to provide an extremely quiet stream line fan cut off.

Unit Heaters

Unit Heaters

Highboy

The New Buffalo Highboy and Lowboy Heaters, units of large capacity, heat and ventilate large areas economically. The heating coils and centrifugal fans are arranged for maximum efficiency. Every part of these heaters is accessible for inspection.

Available in three different lengths and two heights for mounting and may be placed vertically or horizontally.

Mechanical Draft Apparatus

Buffalo Forced and Induced Draft Fans have kept pace with the rapid strides in modern boiler room efficiency. Ruggedness and reliability have always been our watch word. Improvements in efficiency—stronger and better balanced rotors for the higher peak loads—liners and welded construction to combat the erosion of powdered coal are some of the things we are doing and continuing to do.

De Bothezat Impeller Co., Inc.

1922 Park Avenue, **New York, N. Y.**

Branch Offices and Representatives in All Principal Cities

Foreign Office

WEBB DUST REMOVING & DRYING CO., LTD., TIVIOT DALE CHAMBERS, STOCKPORT, ENGLAND
ASANO BUSSAN CO., LTD., 165 BROADWAY, N. Y. OSAKA, JAPAN

Manufacturers of De Bothezat Disc Pressure Fans

48 in. DISC PRESSURE FAN

5 hp. 630 r.p.m. 15,000 c.f.m. against 1-in. s.p. and 28,000 c.f.m. against ⅛-in. s.p.

De Bothezat Fans are guaranteed to have a non-overloading power characteristic, that is to absorb at constant revolutions practically the same power whatever the static pressure under which they are operating for the whole range between free delivery and no delivery. This important property insures the complete safety of their operation under any conditions to be met in practice.

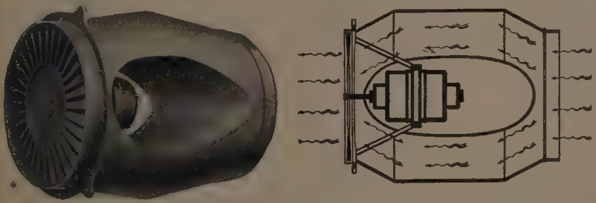
De Bothezat Pressure Fans made in all sizes from 8 in. to 10 ft. Motors for these fans are furnished from $\frac{1}{60}$ hp. to 100 hp. The capacities of the fans run from 350 c.f.m. to 254,000 c.f.m. Static pressure from ⅛ in. to 3 in.

High efficiency and large air volume, together with high pressure characteristics are a few of several qualities which distinguish De Bothezat Disc Pressure Fans.

GIANT FAN

Sizes from 5 ft. to 10 ft.

Powers from 2 hp. to 100 hp. Volume from 16,000 c.f.m. to 254,000 c.f.m. Static Pressure from ⅛ to 2 in. Speed from 175 r.p.m. to 700 r.p.m. Fan and motor mounted on same base securing perfect alignment. Requires minimum floor space. Chain driven, texrope drive, or directly connected



Catalog Supplied on Request

THE BIFURACTOR

For special Ventilating jobs where fumes of excessive temperature or corrosive character are to be removed.

The bifurcator is a device that permits the use of a straightway duct. It eliminates right angle bends and long shaft connections, at the same time protecting and automatically cooling the motor. The fan chamber is stream lined in section, and the bifurcated duct is not reduced in area at this point. Full details on request.

A Few Prominent Users

American Can Company
American Telephone & Telegraph Co.
Bell Telephone Laboratories
Briggs Mfg. Company
Buick Motor Company
City of Detroit
City of New York
Continental Can Company
Detroit Edison Company
Fairbanks Morse Company
General Electric Company
National Biscuit Company
National Tube Company
New York Central R. R. Co.
Packard Motor Company
Pennsylvania Railroad Co.
Philadelphia Gas Company
Public Service Corporation of N. J.
Standard Oil Company of N. J.
United Electric Light & Power Co.
Western Electric Company
Western Union Tele. Co.
Westinghouse Elec. & Mfg. Co.
West Leechburg Steel Co.

30 in. DISC PRESSURE FAN

2 hp., 1140 r.p.m., 8000 c.f.m. against 1-in s.p. and 12000 c.f.m. against ⅛-in. s.p.

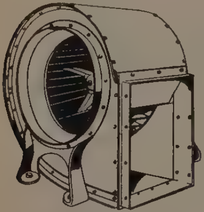
GARDEN CITY FAN CO

Manufacturers Since 1879

McCormick Building **Chicago, Ill.**

Eastern Office: 55 West 42nd Street, New York

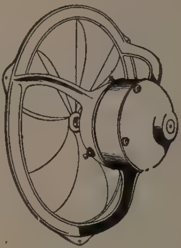
Fans, Blowers; Exhausters; Unit Heaters; Pressure Blowers; Dust Collecting; Ventilating and Drying Apparatus


Cycloidal Multi-Blade Fan

Cycloidal Multi-Blade Fan—Sturdy construction and designed to develop an efficiency equal to any fan of this type built. Overhung wheel and overhung pulley types, suitable for Heating, Ventilating, Drying and Exhausting. Catalog No. 200 contains complete data.

Hi-Static Colodial Fans

Hi-Static Cycloidal Fans are designed for use in connection with Dust Collecting Systems, and for conveying materials of all kinds. **Low Speed Power Saving.** Catalog No. 410 contains complete description and engineering data.


Type "A" Propeller Fan

Type "A" Propeller Fan—For exhausting foul air, steam, smoke, etc. With direct connected motors or furnished with pulleys for belt drive. Bulletin 310 contains data on various types and all sizes. Standard makes of motors used, ample in size. No overload, no heating and thus no cooling device required.

Cyclo-Fin Unit Heater—(Industrial Type)—Compact, sturdy, noiseless and fitted with heavy duty motors for severe and continuous industrial service. Heating element copper tubing with fins. Non-corrosive. Made in both suspension and floor types.

Cyclo-Fin Unit Heater

OTHER PRODUCTS

Centrifugal Compressors—For oil and gas burning—Catalog No. 301.

Positive Pressure Blowers—For Pressures up to 5 lb.—Catalog No. 290.

Forced and Induced Draft Fans.

Blast Gates. Dust Collectors.

Forge Blowers—Fan Coolers.

Garden City products are a combination of genuine quality and efficiency. Fifty years of experience enables us to furnish **"A Fan or Blower for Any Purpose."** A complete set of literature should be in your files.

ILG Electric Ventilating Company

Electric Ventilators—Unit Heaters—Blowers

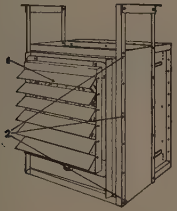
2880 North Crawford Avenue, **Chicago, Ill.**

Branch Offices

SEATTLE	L. C. Smith Bldg.	MILWAUKEE	326 Metropolitan Bldg.
DENVER	Box 968	DES MOINES	Box 57
SAN ANTONIO	118 Redondo St.	BALTIMORE	Hearst Tower Bldg.
NEW YORK	15 Park Row	NEW HAVEN	902 Chapel St.
CLEVELAND	1105 Schofield Bldg.	INDIANAPOLIS	817 Architects & Builders Bldg.
PHILADELPHIA	325 Commercial Trust Bldg.	MINNEAPOLIS	442 Builders Exch. Bldg.
PITTSBURGH	1018 Bessemer Bldg.	KANSAS CITY	524 Ridge Bldg.
DETROIT	415 Brainard St.	LOS ANGELES	406 S. Main St.
ST. LOUIS	1421 Syndicate Trust Bldg.	NEW ORLEANS	203 Natchez Bldg.
CINCINNATI	622 Broadway	BOSTON	136 Federal St.

Sales Representatives in All Principal Cities

ILG ELECTRIC VENTILATION

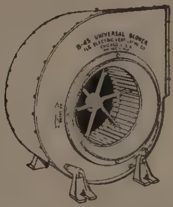


ILG Unit Heaters

ILG Unit Heaters solve the most vital problem in Economical Heating. They insure equalized distribution of the heat waves and spread and hold the warm air to the breathing zone. This distinctive feature of ILG Unit Heaters is protected by basic patent No. 1295151.

Using live air tempered with steam or hot water, ILG Unit Heaters take the air at *low* velocity and deliver it to the floor level at *high* velocity. The range of action of the heat waves is from 60 to 100 ft. There are no cold air pockets, no ceiling hot spots—the temperature variation between floor and ceiling is less than 15 deg.

ILG Unit Heaters are recommended for factories, warehouses, garages, aircraft buildings, public buildings, gymnasiums, locker rooms, store and hotel lobbies, etc. Write for new Illustrated Book of special interest to heating engineers.



ILG Blowers

Good engineering has made ILG Direct Connected Blowers a notable example of compactness, combining unusual strength with minimum weight. The simplicity of assembly makes for quiet operation, low power consumption, and economical upkeep.

The motor is a built-in feature. It is made an integral part of the housing. No foundation is required for motor or blower—simply fasten the four legs to the floor or ceiling.

ILG Direct Connected Blowers are made with interchangeable bowl and inlet flange. This construction makes it easy to change drive. All ILG Blowers are tested at the factory on actual current and voltage of the circuit on which they will be used—the guarantee covers the complete unit.

Detailed information as to sizes, capacity, etc., mailed on request.

HIGH EFFICIENCY
TRADE
ILG
MARK
VENTILATING MACHINERY

Ventilation

For Offices, Stores, Factories, Restaurants, Theatres, Public Buildings, Homes, etc., etc.

Johnson Fan and Blower Co.

1317 West Lake Street, **Chicago, Ill.**

Manufacturers of

Propeller Fans, Volume Blowers (Multivane Type), Pressure Blowers, Roof Ventilators (Motor Driven), Penthouses, Extended Shaft Fans, Low Speed Exhausters, Unit Heaters.

Offices in Principal Cities

PROPELLER FANS

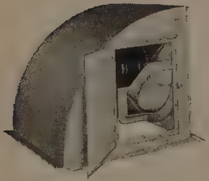
Every Johnson Propeller Fan is "precision" built and designed on correct ventilating and engineering practice and principles.

The outer ring, arms and motor platform are cast in one piece, thus eliminating bolts and preventing frame from getting out of alignment, during shipment or installation.

40 deg. motors used throughout and enclosed at front to prevent grease, dirt, acid fumes and other injurious substances from injuring windings. Motors are interchangeable, so that the use of only one frame is required for direct current or alternating current.

Furnished in sizes from 12 to 72 in., for any current or voltage.

Send for catalog No. 12, containing detailed information.



ROOF VENTILATORS (Motor Driven)

The design of Johnson Motor Driven Roof Ventilators, embodies a new method of construction, so that all joints are completely sealed, preventing leakage during inclement weather.

The rounded shape or graduated slope of housing greatly assists drainage in wet weather, thereby preventing injury to fan and motor.

Built in single or double compartment types. In double compartment type, the motor, being enclosed in a separate but easily accessible chamber, is protected from fumes or acids.

Write for bulletin No. 25, which contains full data and specifications.

VOLUME BLOWERS

Johnson Blowers are carefully constructed of the best materials. They are designed not only to be able to obtain maximum efficiency, but also, flexibility and ease of installation.

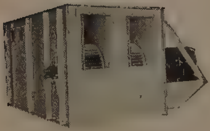
The construction admits of eight different position of discharges, both right and left hand.

Discharge velocity—in Johnson ratings—are based on the distance from the point of cut-off to the *nearest* point of the outer scroll. Built for any type of drive. Sizes from No. 30 up are regularly equipped with Self-Aligning Ball Bearings.

Capacities range from 225 c.f.m. at ½ in. static pressure to 161,000 c.f.m. at 2 in. static pressure.

Made in wheel diameters from 6 to 90 in.

Catalog No. 25 gives complete data.



UNIT HEATERS

Johnson Unit Heaters cover a wider range of sizes and types than can be obtained in any other make.

The Propeller Fan Types are built for either ceiling suspension or floor mounting. The High Velocity Blower Type Unit Heaters cover a wide range, for either ceiling suspension or floor mounting.

The method of "High Velocity" Unit Heating was originated and pioneered by Johnson.

This method adequately meets the requirements for heating interiors where ceilings are high and areas large. With this method fewer unit heaters per area are required and quicker heat in a given area is obtained.

Bulletin No. 56 contains valuable engineering data and detailed information.

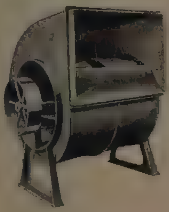
PHONE CALUMET 6650

FANS AND BLOWERS
AIR FILTERS AND WASHERS
FAN FURNACES
UNIT-HEATERS

The
NEW YORK BLOWER COMPANY

GENERAL OFFICES
3169 SHIELDS AVE.
ARMOUR P. O. STA.
CHICAGO, ILL.

FACTORIES AT LA PORTE, IND. AND CHICAGO, ILL.



Type ME Fan

Type ME Fans cover a wide range of capacities from 100 c.f.m. to 300,000 c.f.m. Sizes up to and including No. 39 made with cast iron inlet stands and are reversible, the larger sizes made non-reversible. Fans deliver large quantities of air at high efficiency. Cone Back Multi-Blade Wheels with forward curved floats used exclusively. Fans are regularly made either with overhung pulley or overhung wheel of all hands and discharges.

We also manufacture Fans for mechanical draft, conveying systems, foundries, gas plants and stokers.

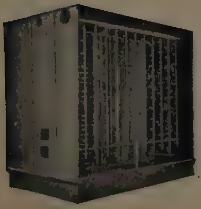
Write for Catalog No. 100 containing complete data.

Comet Unit-Heaters

For use with steam. Made in two sizes, as shown in table. A Heavy Duty Disc Fan direct connected to motor drives air over heating coils. Unit-Heaters using pipe coil and vento made in convenient sizes.

Write for Catalog 105 which gives complete data including B.t.u. capacities under various conditions.

Size Heater	Cu. Ft. per Min.	Cu. Ft. per Hour	Motor		Dimensions			E.D.R.	Wght. Complete
			R.P.M.	H.P.	Height	Width	Depth		
8	800	48,000	1050	1/20	15	15	8	240	80
18	1800	108,000	850	1/10	23	23	12½	540	200
24	2400	144,000	1160	1/6	23	23	12½	720	200
60	6000	360,000	680	1/2	34	34	15¼	1800	550



Air-Washers and Humidifiers

Peerless Air-Washers and Humidifiers, Type "D" and "E," with capacities ranging from 3600 c.f.m. to 112,000 c.f.m. of value for washing, drying, humidifying and cooling. Also for special processes as paper, textiles, tobacco, glue, leather and wood.

Write for more detailed descriptive literature.

B. F. Sturtevant Co.

Hyde Park, Boston, Mass.

Sturtevant

Atlanta, Ga.
Boston, Mass.
Buffalo, N. Y.
Camden, N. J.
Charlotte, N. C.
Chicago, Ill.
Cincinnati, O.
Cleveland, O.
Dallas, Tex.
Denver, Colo.
Detroit, Mich.
Hartford, Conn.
Indianapolis, Ind.
Kansas City, Mo.

PLANTS LOCATED IN

Camden, N. J. Hyde Park, Mass. Framingham, Mass.
Sturtevant, Wis. Galt, Ont. Berkeley, Calif.

Los Angeles, Cal.
Milwaukee, Wis.
Minneapolis, Minn.
Montreal, P. Q.
Newark, N. J.
New York, N. Y.
Omaha, Neb.
Pittsburgh, Pa.
Portland, Ore.
Rochester, N. Y.
St. Louis, Mo.
San Francisco, Cal.
Seattle, Wash.
Toronto, Ont.
Washington, D. C.

STURTEVANT PRODUCTS

The wide application of Sturtevant Products can hardly be discussed here; so for the convenience of the architect, engineer and contractor the publications listed below have been prepared to aid in the selection of proper equipment for industrial, public, and private buildings of all types and sizes. We will gladly send you any of these publications on request.

ENGINEERING SERVICE

Each office, address shown above, maintains a force of trained engineers who are always ready to analyze the conditions of any prospective installation and make recommendations for suitable equipment.

CATALOGS

Heating and Ventilating Equipment

No. 230 Heaters.
271 Multivane Fans.
357 Disc and Propeller Fans.
283 Autoforce Ventilators.
290 Silentvane Fans.
295 Air Washers.
327 Portable Disc Fan.
332 Ventilating Sets.
337 Monogram Fans.
340 Ventilating Fans.
361 Unit Ventilators.
363 Tempervane Heaters
370 Convertible Multivane Fans.
345 Carbon Monoxide Asphyxiation and Its Prevention.
No. 349 Coal Burning Blowers.
1011 Heating and Ventilating Picture Book, Factory Section.
1012 Heating and Ventilating Picture Book, School Section.
1013 Heating and Ventilating Picture Book, Public Building Section.
1014 Heating and Ventilating Picture Book, National, State and County Building Section.
1016 Heating and Ventilating Watervliet, N. Y. Shops D. & H. Railroad.

Power Plant Equipment

No. 275 Gear Transmissions.
288 Forced and Induced Draft with Mechanical Stokers.
311 Steam Turbines, Type 12.
330 Turbovane Fans, Designs 4 and 5.
331 Air Economizers.
346 Propeller Type Forced Draft Fan.
349 Coal Burning Blowers.
360 Discussion of Fans for Mechanical Draft.

Vacuum Cleaning Equipment

No. 362 Vacuum Cleaner, Furnace and Boiler Cleaning.
367 Portable Vacuum Cleaners.
368 Stationary Vacuum Cleaners.

L. J. Wing Mfg. Co.

Branch Offices in Principal Cities

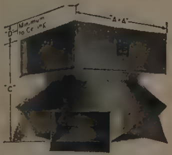
59 Seventh Avenue, **New York**
PHONE: CHELSEA 0027-0030

Factory:
NEWARK, N. J.

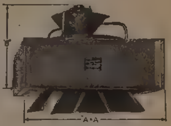
Manufacturers of Wing Featherweight Unit Heaters, Wing Turbine and Motor Driven Blowers, Wing-Scruplex Fans, Exhausters, Fog Eliminators

---

The Wing Featherweight Unit Heater



Type LC Unit—motor and fan below heating element allowing location close to ceiling. Also used with fresh air duct.



Type HC Unit—motor and fan above heating element for use with a variety of discharges. Design 1 Vane Discharge shown.

An unusually light, compact overhead heater, not dependent on side walls, partitions, pillars or girders for support, but placed wherever it will give the best results with any type roof construction without reinforcement. Its discharge is downward from immediately over the area to be heated, so that the air it heats can be directed in all, or in any desired, directions. Another advantage of this central location is that one unit or a single row will often cover areas that would require three or four times the number of units if the discharge were in but one direction.

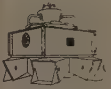
A variety of standard discharge designs shown on this page adapt Wing Featherweight Unit Heaters for use over different shaped areas and for different heights from the floor, securing the proper diffusion of the heated air.

The highly efficient Wing Scruplex propeller-type fan obtains the high velocity of discharge necessary to penetrate the cooler air beneath. The whole building is maintained at a remarkably uniform temperature, with no areas overheated, and none too cold.

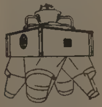
The forced diffusion of warmed air through the whole working area reduces the usual initial heating-up period to an absolute minimum.

Since Wing Featherweight Unit Heaters are easily controlled by hand or by thermostatic switch, they are shut off when the building gets too hot, instead of wasting steam by opening windows.

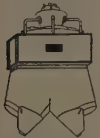
A considerable economy is effected by the prevention of wasteful accumulation of overheated air overhead, for Wing Units are constantly removing the hot air from overhead further heating it and diffusing it through the cooler air at the working level. The temperature between the floor and the roof levels of a Wing heated building varies only a fraction of a degree per foot height.



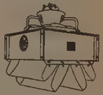
Design 5—square areas—from low position.



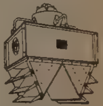
Design 7—square areas—fairly high.



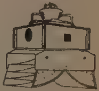
Design 8—long narrow areas—high location.



Design 2—long narrow areas—moderate heights.



Design 3—alternative for Design 2 for lower installation—small heaters.



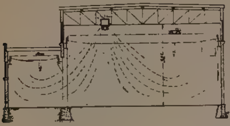
Design 4—alternative for Design 2—larger heaters.

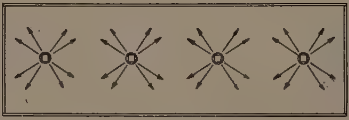
Railroad Machine Shop with Type HC Unit, Design 1 Discharge, 40 ft. above floor, covering practically oblong areas

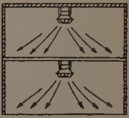
Chair factory with Type LC Units. Minimum space to ceiling. Regular 4-way discharge spreads heat over wide area.

Methods of Installing Wing Units

The drawings below show typical high ceiling and low ceiling installations, together with a plan view illustrating the general distribution and diffusion of the heated air from the unit heaters. The first illustration shows Type HC heater installed 30 or more feet from the floor, above the travelling crane, the heater arranged so that the left, lower portion of the building is also heated. The third illustrations shows a typical multi-story building heated with Type LC heaters.







Condensed Table of Engineering Data

(Letters refer to dimensions indicated on illustrations at top of preceding page)

Unit Size	AxA, In.	B, In.	C, In.	D, In.	Air, C.f.m.	Motor, Hp.	Temperature		B.t.u. per Hr. Available	Approximate Shipping Weight, Lb.
							Room	Leav.		
13-4-12	19¾	26½	24	6	1150	⅛	60	110	57,100	185
17-3-12	22¾	28	26	6	1950	¼	60	110	96,900	213
22-3-12	27¾	29	26	6	3200	¼	60	112	162,000	270
22-4-12	27¾	29	26	6	2800	¼	60	122	169,000	280
22-5-12	27¾	29	26	6	2600	¼	60	133	180,000	288
25-4-12	32¾	30½	28½	7	4800	½	60	122	289,500	320
25-5-12	32¾	30½	28½	7	4500	½	60	133	311,400	332
30-4-85	40⅛	36	38	8	6900	1	60	122	416,000	360
30-5-85	40⅛	36	38	8	6500	1	60	133	450,000	365
36-4-85	46⅛	42	42	8	9600	2	60	122	579,000	504
36-5-85	46⅛	42	42	8	9000	2	60	133	623,000	528

Complete table for other room temperatures will be furnished on request.

Wing Fog Eliminators

Wing Fog Eliminators supply tempered fresh air to completely de-fog dyehouses, bottling, preserving and pasteurizing plants, paper mills, and in general any building or room where steam, fog or fumes are liberated in manufacturing processes.

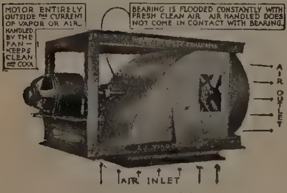
The Wing Scruplex Fan

Its true screw-propeller design moves **all** the air straight forward without eddy. Current consumption is low.

The motor is generously proportioned, totally inclosed, easily accessible. Pully or turbine drive also furnished.

Wing Scruplex Fans are built in the following sizes: 10, 13, 17, 22, 25, 30, 36, 42, 48, 54 and 60 in.—capacities from 950 c.f.m. to 33,000 c.f.m. Up to 25 in. diameter propellers are made of cast aluminum—larger sizes of pressed steel.

Wing-Scruplex Fan



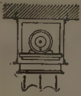
MOTOR ENTIRELY OUTSIDE THE CURRENT OF VAPOR OR AIR HANDLED BY THE FAN—KEEPS CLEAN AND COOL
BEARING IS FLOODED CONSTANTLY WITH FRESH CLEAN AIR. AIR HANDLED DOES NOT COME IN CONTACT WITH BEARING.
AIR OUTLET
AIR INLET

Wing-Scruplex Exhauster

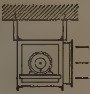
Wing-Scruplex Exhausters

Wing Scruplex Exhausters consist of the highly efficient "screw propeller" fan encased in appropriate manner with a motor on the outside where it is clean, cool and easy of access. They are used in duct work where the resistance is low and being designed in the form of an elbow fit snugly in any line. The diagrams at top of next page show the methods of installation.

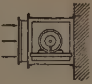
Proper Selection of Exhausters



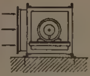
Bolted directly to Ceiling



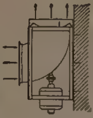
Hung from Ceiling



Bolted directly to Side Wall



Bolted to Floor or Foundation



Vertical Bolted to Side Wall

Where particularly quiet operation is desired, as in offices, residences, hospital wards, etc., use lowest speeds in all sizes in the table below. For toilet rooms, laboratories, motion picture booths, stock-rooms, etc., use any speed in sizes 1 and 2; low and medium speeds in all other sizes. In industrial plants, engine-rooms, workshops, etc., use any speeds.

Capacities of Wing-Scruplex Exhausters up to 0.5″ static.

Size	Inlet Sq. In.	Outlet Round In.	Speed R.p.m.	Free Air		.15 in.		.25 in.		.40 in.		.50 in.	
				C.f.m.	Hp.	C.f.m.	Hp.	C.f.m.	Hp.	C.f.m.	Hp.	C.f.m.	Hp.
1-A	10	10½	1750	850	0.052	630	0.054	330	0.060	......	......	......	......
2-A	13½	14⅛	1150	1440	0.060	950	0.069	395	0.090	......	......	......	......
2-B	13½	14⅛	1750	2050	0.195	1895	0.208	1695	0.216	1155	0.248	750	0.285
3-S	16¾	17⅜	850	2130	0.090	1250	0.110	......	......	......	......	......	......
3-A	16¾	17⅜	1150	2700	0.180	2150	0.195	1550	0.221	......	......	......	......
3-C	16¾	17⅜	1750	4000	0.600	3720	0.635	3510	0.655	3150	0.700	2810	0.720
4-S	21	21¾	850	2850	0.100	2200	0.100	1610	0.125	......	......	......	......
4-A	21	21¾	1150	3575	0.170	3150	0.200	2775	0.220	1950	0.245	1550	0.280
4-C	21	21¾	1750	5400	0.540	5160	0.600	4990	0.650	4670	0.710	4440	0.750
5-A	25	25	1150	5200	0.330	4720	0.380	4250	0.440	3300	0.530	2610	0.600
5-B	25	25	1750	8000	1.330	7740	1.360	7540	1.400	7175	1.480	6900	1.540
6-A	30	30	600	5500	0.210	3725	0.250	2375	0.330	......	......	......	......
6-B	30	30	850	7400	0.550	6280	0.600	5450	0.740	4000	0.830	3400	0.960
6-C	30	30	1150	10250	1.500	9520	1.550	8950	1.570	8000	1.620	7340	1.760

Complete data on request

Acid Resisting Monel Metal Fans and Exhausters

For handling acid laden air, Wing Scruplex Exhausters and Wing Scruplex Fans are supplied with all parts that come in contact with the air exhausted, made of Monel Metal.

Wing Blowers for Forced Draft

Wing motor-driven Type EM Blowers are chosen for forced draft for heating boilers of all sizes because they maintain the same high standards which have made the Wing Turbine Blower a standard in forced draft equipment for pressure boilers for 25 years.

The installation of a Wing Unit makes possible the use of Buckwheat coal and other inexpensive fuels with great savings in fuel costs, which usually pay for the blower in the first year of operation.

These blowers are of the propeller type fan construction, which affords large air passages and low air velocities, resulting in quiet operation and even fires.

Wing Blowers are controlled by speed regulation, conveniently operated from the front of the boiler. Totally enclosed motors keep out the dust and dirt of the boiler room, insuring many years of service without repair. Automatically controlled, they make the fireman's work easier.

Wing EM Blower

The Wing Blower in foreground supplies forced draft to hot water supply heater; while blower in background serves two return tubular heating boilers

Ask for Bulletin No. 46 describing Wing EM Units, and Bulletin No. 87 describing Turbine Blowers.

Armstrong Cork & Insulation Company

Lancaster, Pa.

Offices

Albany
Atlanta
Birmingham
Boston
Buffalo
Charlotte, N.C.
Chicago
Cincinnati
Cleveland
Dallas
Denver
Detroit
Houston, Tex.
Jacksonville, Fla.
Kansas City
Memphis
Milwaukee
Minneapolis
New York
Pittsburgh
Rochester
St. Louis
Montreal, Que., Can.
Toronto 2, Ont., Can.
Armstrong Cork Company, Ltd., London, England

Representatives

Baltimore	John R. Livezey	San Francisco	Van Fleet-Freear Co.
Los Angeles	Gay Engineering Corp.	Seattle	D. E. Fryer & Co.
New Orleans	H. T. Steffee	Spokane	D. E. Fryer & Co.
Philadelphia	John R. Livezey	Tacoma	D. E. Fryer & Co.
Portland	Gillen-Cole Co.	Washington	John R. Livezey

Detailed information, samples, and descriptive literature may be obtained on application to any of these offices or representatives.

Armstrong's Cork Machinery Isolation is a special grade of corkboard for absorbing noise and vibration under moving machines such as fans, motors, etc.

The natural resilience of cork and the fact that it does not "set" under pressure nor harden with age make it especially suitable for this use.

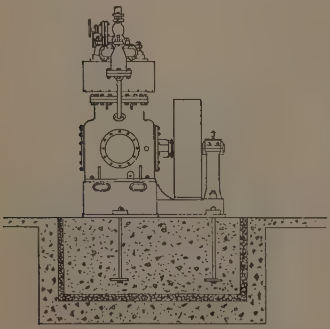
Another advantage of Armstrong's Cork Machinery Isolation is that, being a manufactured product, its density can be varied to suit different conditions. Armstrong's is made in three grades or densities from 1.1 to 1.66 lb. per board foot. By adapting the grade to weight and type of machine, much better results are obtained than by using a single grade for all installations.

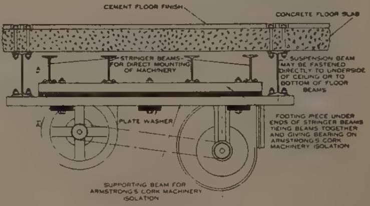
Armstrong's Cork Machinery Isolation is made in boards 12 by 36 by 1, 1½, 2, 3, 4, 5 and 6 in. thick. The standard boards may be sawed or cut into the desired shape or size as readily as lumber, and where large pads are required, they can be made in sections and cemented together.

The density and thickness to be used cannot be determined accurately until such factors as the weight, speed and character of the machine to be isolated are known. Generally speaking, the grades which should be used under different classes of machines are as follows:

Small fans, motors, generators, etc.	Light
Large fans, medium size motors and generators, light machines and machine tools, etc.	Medium
Heavy motors and generators, large machines and machine tools, engines, etc.	Heavy

Two methods of installing Armstrong's Cork Machinery Isolation are usually followed. In the first, the foundation pits are lined with Armstrong's Cork Machinery Isolation on the bottom and sides. The foundation proper is then poured in on top of the cork. In the second, the cork is placed between the base of the machine and the foundation, floor or ceiling, to which it is fastened. See figures below.

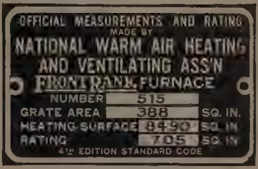



CEMENT FLOOR FINISH
CONCRETE FLOOR SLAB
STRINGER BEAMS FOR DIRECT MOUNTING OF MACHINERY
SUSPENSION BEAM MAY BE FASTENED DIRECTLY TO UNDERSIDE OF CEILING OR TO BOTTOM OF FLOOR BEAMS
PLATE WASHER
FOOTING PIECE UNDER ENDS OF STRINGER BEAMS TIEING BEAMS TOGETHER AND GIVING BEARING ON ARMSTRONG'S CORK MACHINERY ISOLATION
SUPPORTING BEAM FOR ARMSTRONG'S CORK MACHINERY ISOLATION

Langenberg Manufacturing Co.

4549 No. Euclid Ave. :-: St. Louis, Mo.

HEATING
FRONT RANK
TRADE NAME REGISTERED
SYSTEMS



OFFICIAL MEASUREMENTS AND RATING
MADE BY
NATIONAL WARM AIR HEATING
AND VENTILATING ASS'N
FRONT RANK FURNACE
NUMBER 515
GRATE AREA 388 SQ. IN.
HEATING SURFACE 8490 SQ. IN.
RATING 705 SQ. IN.
4TH EDITION STANDARD CODE

A new way of heating homes, churches and schools is to combine the heating and ventilating apparatus into a single unit under automatic control.

The Front Rank is such a system—equipped with fan, vapor supply, air filters, etc.

Stratification is reduced by a positive air movement thus providing a higher degree of comfort than is ordinarily possible. Air conditions are under control. Wind pressures are overcome. The system occupies no usable space in the parts of the building to be heated.

In small buildings the Standard Code is followed. In large buildings modern engineering principles are used in accurately computing heat losses and estimating required capacities.

Each system is designed especially for the building in which it is to be erected.

We have specialized in good Warm Air Heating since 1888.

No. of Furnace*	Overall Height In.	Grate Area Sq. In.	Ratio: Heating Surface Grate Area	Rating Sq. In.	Size Feed Door Sq. In.	Size Ash Door Sq. In.
381	68	177	36.1	350	10 x12	8¼x11½
455	72	258	28.6	529	8¾x12½	10 x15½
515	73	388	21.9	705	8¾x12½	10 x15¼
575	75	471	21.8	853	8¾x12½	12¼x14
635	75	578	20.0	1015	8¾x12½	12¼x14
665	89	578	24.0	1093	8¾x12½	12¼x14

*First two figures of number are diameter of casing.

The above data in connection with the Standard Code, published as a part of the Chapter on Gravity Warm Air Heating, will enable the Architect, Engineer or Contractor to specify the correct size Front Rank furnace for any project.

Any Front Rank furnace installed by an authorized dealer according to the Standard Code is guaranteed to maintain an average temperature of 70 deg. in zero weather.

Ellison Draft Gage Company

214 West Kinzie Street :-: Chicago, Ill.

Products:

Ellison Draft Gages, Pilot Tubes and Steam Calorimeters. Designed by Lewis M. Ellison and manufactured by Ellison Draft Gage Company.

Ellison Pointer Draft Gages:

Straight-Line Movement: This improved pointer draft gage, converting an arc into a straight line, is of remarkable accuracy and repeats precisely. It is of unusual substantial construction and is made in 1 to 12 readings, wall or panel type, with color code system of drafts. It has a powerful bell of 10 cu. in. displacement. The fulcrum knife edges are of hardened steel, ¼ in. long. The bells have a common pan, with drain, and the liquid used is mineral oil. The pan is filled thru a large tube in the side or back, combining a filler and liquid level indicator.

The scales are 10 in. long, of uniform spacing, and are illuminated from the back with a standard 15 watt bulb, one for eight pointers.

Dial Type: Of the same excellent construction and accuracy as the straight-line type, having the same filler, knife edges, beam and bell, using the same liquid.

It is made in four sizes, up to 5 in. range or in mm. graduations, minus or plus, and in one, two and three pointer gages. The two-pointer is intended for furnace and uptake or pit pressure and furnace, and the three-pointer for pit, furnace and uptake.

The scale is 10 in. long, with large figures, readings visible across the boiler room.

Ellison Tube Draft Gages:

The famous Ellison Inclined Tube Gage, is the original—not an imitation and is recognized the standard of accuracy. Was introduced in 1896. Water having a variable movement, a mineral oil is used. Except the inclined-vertical type, all the gages have sliding scales for setting zero, requiring no frequent refilling. The stationary gages have white enameled scales, and the open type inclined gages, white metal scales, with micrometer leveler.

Inclined Draft Gage: Made in .3 in. range for domestic furnaces and in ½, 1, 2, 3, 4, 5, 6 and 7½ in. range, and in mm., for power boilers, suction, pressure or differential.

Combination Inclined Draft Gage: By turning the handle, this gage reads furnace, flue or differential draft in 1 and 1½ in. range, and in mm.

Compound Inclined Draft Gage: This gage reads furnace draft to left, flue draft or differential to right of zero in in. and mm. scales.

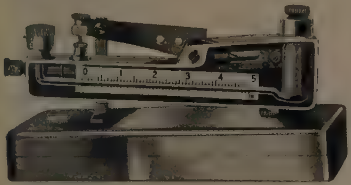
Multi-Tube Inclined Draft Gage: Made in 2, 3 and 4 tubes in 1 to 7½ in. range, and in mm., suction, pressure or differential.

Pointer Air Filter Gage: Indicates differential thru air filters and the time for cleaning. The type is same as the dial type gages. Made in ½ and 1 in. range, and in mm.

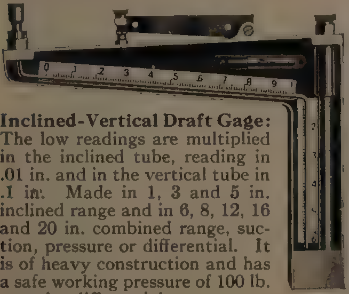
Differential system furnished for any of the inclined gages for Pitot tubes and other differential readings, which prevents the liquid blowing out with static pressures in excess of the scale range.

Ellison-Pitot Tube is of the standard type and is of superior construction—inner tube of "Nickel Silver."

Inclined Draft Gage—Open Type: For technical institutions and power plant testing. With sliding scale and micrometer leveler. Made in 1, 1½, 2, 3 and 5 in. range, and in mm., suction, pressure or differential.



Portable Inclined Draft Gage: For traveling engineers, light and compact, with leveling stand. Made in ½, 1, 1½ and 2 in. range. Also two-tube in ½ and 1 in. and in ½ and 1½ in. ranges. All gages with or without attachments and pressed aluminum carrying cases.

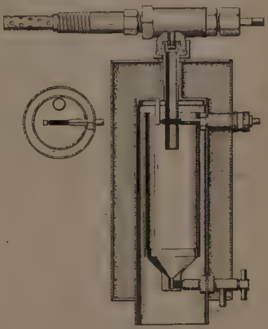


Inclined-Vertical Draft Gage: The low readings are multiplied in the inclined tube, reading in .01 in. and in the vertical tube in .1 in. Made in 1, 3 and 5 in. inclined range and in 6, 8, 12, 16 and 20 in. combined range, suction, pressure or differential. It is of heavy construction and has a safe working pressure of 100 lb. —under differential.

Vertical Draft Gages: The open type is for portable use and is made in 5 and 10 in. range, and in oz. Also in 4, 7 and 12 in. range in the sliding scale type. The single tube cover type is for stationary use and is made in 4, 7, 12, 20 and 30 in. range, and in cm. and oz. In multi-tube it is made in 2 to 10 tubes 7 in. range, 3 to 12 tubes 10 in. range, 3 to 6 tubes 15 and 20 in ranges.

Ellison U Path Steam Calorimeter:

In this recently improved steam calorimeter, a remarkable performance of 2 degrees within the theoretical temperature is obtained.



Steam enters and escapes at the top of the steam chamber, forming a **U** path. Momentary excess moisture is separated and re-evaporated by the superheated steam, lowering the temperature on the superheat thermometer in direct proportion. This cycle forms a throttling, separating and re-evaporating calorimeter in a single steam chamber, which is steam jacketed by the down-flow escaping steam. The jacket steam is protected against chilling by a 1 in. insulating jacket on the sides and 1½ in. on the top of the jacket, which is filled with lamp black and encased by a bright nickel plated casing.

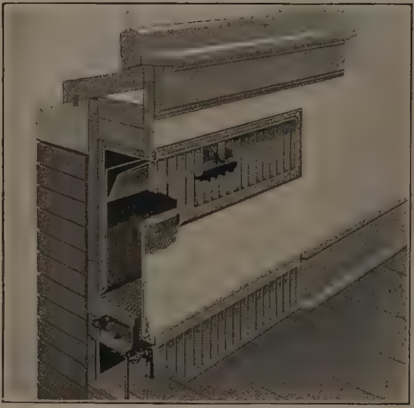
The Trane Company

La Crosse, Wis.

See Pumps, page 766; Unit Heaters, page 679; Heating Specialties, pages 838, 839.

BRANCHES IN ALL PRINCIPAL CITIES

TRANE CONCEALED HEATING



Concealed Heating is recognized as the modern method of distributing heat in homes, apartments, office and public buildings. Trane as a pioneer in this field has developed the Concealed Heater and simplified the installation until the job of setting the unit in the wall and making the piping connections is comparatively easy. The installation can be made in about the same time it requires to set a radiator.

One of the big advantages of Trane Concealed Heating is in the adjustable stack which connects the heating element with the outlet grille. This feature has entirely removed the necessity of minutely measured wall openings and does away with the difficulty of making the installation. The stack has a wide height range which gives a variety of capacities in a single unit.

Trane Concealed Heaters are made in three widths— 3⅝, 5⅝ and 7⅝ in. The first two fit in 2 x 4 in. and 2 x 6 in. walls respectively without furring. The heaters are made in the following lengths: 22, 30, 36, 42, 48, 54 in.

The grilles—the only part of the installation which can be seen—are cast aluminum in the Standard and Dutch Colonial Style. The Stamped Steel Style Grille is also available.

Heat Control can be obtained either through the use of a damper on the outlet grille or by a valve on the heating element.

Heater is always accessible for inspection and can easily be removed without interfering with the plastering.

Trane Heat Cabinets are ideal for homes already built where the owner wishes to have the advantages of convection heat but does not want to make the installation between the walls. Price compares favorably with cast iron radiator and shield.

Capacities of Trane Unit Heaters

AT 5 LB. STEAM PRESSURE FOR 60 CYCLE AND DIRECT CURRENT ONLY

No. 12 High Speed

Power—60 Watts—1/20 h.p. **1500 R. P. M.** **485 C. F. M.**

Inlet Air Temperature	Temperature Rise	Final Temperature	B.t.u. Per Hour	Pounds of Condensate Per Hour	Sq. Ft. E. D. R.
50°	88°	138°	46,000	47	192
60°	83°	143°	43,400	45	181
70°	78°	148°	40,800	42	170

No. 15 High Speed

Power—160 Watts—1/6 h.p. **1140 R. P. M.** **1280 C. F. M.**

Inlet Air Temperature	Temperature Rise	Final Temperature	B.t.u. Per Hour	Pounds of Condensate Per Hour	Sq. Ft. E. D. R.
50°	69°	119°	92,000	96	383
60°	65°	125°	86,600	90	361
70°	62°	132°	81,500	85	340

No. 18 High Speed

Power—240 Watts—1/6 h.p. **1140 R. P. M.** **2060 C. F. M.**

Inlet Air Temperature	Temperature Rise	Final Temperature	B.t.u. Per Hour	Pounds of Condensate Per Hour	Sq. Ft. E. D. R.
50°	66°	116°	147,500	153	615
60°	63°	123°	139,000	145	579
70°	59°	129°	130,800	136	545

No. 24 High Speed

Power—260 Watts—1/6 h.p. **1140 R. P. M.** **2910 C. F. M.**

Inlet Air Temperature	Temperature Rise	Final Temperature	B.t.u. Per Hour	Pounds of Condensate Per Hour	Sq. Ft. E. D. R.
50°	68°	118°	212,100	221	885
60°	64°	124°	200,000	208	834
70°	60°	130°	188,400	196	785

No. 24-A High Velocity

Power—660 Watts—1/2 h.p. **1140 R. P. M.** **4070 C. F. M.**

Inlet Air Temperature	Temperature Rise	Final Temperature	B.t.u. Per Hour	Pounds of Condensate Per Hour	Sq. Ft. E. D. R.
50°	63	113°	275,000	286	1150
60°	59°	119°	260,000	270	1085
70°	56°	126°	244,000	254	1020

Note.—All air volumes based on dry air at 70° F.

CIRCULAIR HEAT, INC.

Representatives
in All
Principal Cities

Circulair
HEAT

General Offices
202 Central Ave.,
Louisville, Ky.

Circulair Heat Installed Under Window. Standard Outlet Grille

Circulair Heat is an improved convection heating unit of the concealed type for use with hot water, steam, vacuum or vapor systems in place of cast iron radiators.

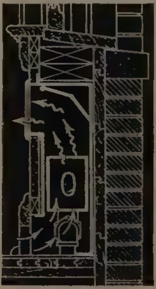
The Circulair Heat Unit occupies only a fraction of the space required normally for room heating equipment and consists of a carefully designed seamless copper tube on which are pressed die-stamped fins evenly spaced. Circulair Units are available in various widths and lengths and may be concealed in walls or cabinets.

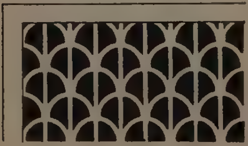
The Concealed Circulair Heater is usually plastered in the wall but a removable plaster wall panel is available where ready access to piping, valves and traps is desired. This plaster panel is plastered on the job when the wall is plastered and is invisible when the wall is finished.

Circulair Heat Units are rated in equivalent square feet of cast iron radiation. All ratings are based on 240 B.t.u. per square foot and were established by actual condensation tests. Capacities depend upon (1) Type of heater, (2) Length of heater, (3) Height of stack.

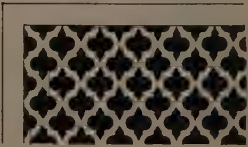
A wide variety of grille designs are available to harmonize with various types of architectural treatment.

For complete engineering and installation data send for latest Circulair catalog.





Type D Grille



Type C Grille

The Dixie Blower Company

1351 West 37th Place, **Chicago, Ill.**
Manufacturers of Dixie Unit Heaters

Dixie Unit Heater

The Dixie Unit Heater is adapted to any service for which a unit heater can be used, including the heating of warehouses, factories, offices, theatres, garages, churches, auditoriums, and many special applications for which a heater of high quality is required.

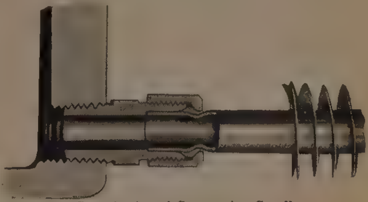
The Dixie Unit Heater is so constructed that it can be either suspended from the steam line or from an overhead support. The direction of the air is regulated by the adjustable shutters, at any angle from a horizontal direction straight down to the floor.

Dixie Unit Heaters are constructed and tested to operate continuously on any steam pressure up to 150 lb. Dixie cores have been tested at several times this pressure and found to be satisfactory. This is made possible by the use of the highest grade material throughout and by the patented compression coupling, which eliminates the possibilities of all leaks between the tubes and the headers. Each tube is inserted in its proper place and the coupling tightened up by hand. Each core is a job in itself.

The tubes of which the Dixie core is constructed are made of heavy weight ⅜ in. seamless copper tubing upon which a spiral copper fin is securely fastened.

Compression Coupling

An outstanding feature of the Dixie Unit Heater is the patented compression couplings employed between the tubes and the headers. These couplings insure a connection which is guaranteed to be leak-proof. A further outstanding feature of this design is the ease with which a tube can be replaced in case of damage. It is only necessary to unscrew the coupling and lift out the tube. The hole in the header can be plugged with a ¼ in. pipe plug and the unit put back into operation. The Unit need not be out of service more than a few minutes, an incalculable advantage where service is required.



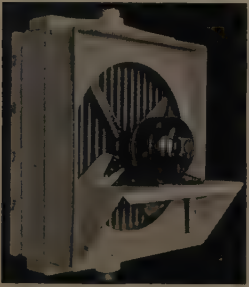
Cross Section of Compression Coupling Used in the Dixie Unit Heater

In a test to determine the holding strength of this compression coupling, 11,000 lb. (2½ tons) pull was exerted trying to pull the headers apart. Although the tubes were stretched nearly one-half inch the compression couplings held perfectly and the unit remained intact.

Ratings at 5 lb. Steam Pressure

	Air Entering Heater °F.	Air Leaving Heater °F.	B.t.u. per Hour	Condensate Lbs. per Hour	Equiv. Sq. Ft. Direct Rad.	Cu. Ft. Air per Minute	Shipping Weight Lbs.
No. 1700	40	130	465240	484	1920	6400	550
	50	136	436500	454	1816	6400	550
	60	141	410680	428	1712	6400	550
	65	143	401000	416	1664	6400	550
	70	144	387020	404	1616	6400	550
No. 800 B	40	130	232620	242	960	3200	230
	50	136	218250	227	908	3200	230
	60	141	205340	214	856	3200	230
	65	143	200500	208	832	3200	230
	70	144	193510	202	808	3200	230
No. 500	40	130	146880	155	612	1300	170
	50	135	138240	146	576	1300	170
	60	143	128880	136	537	1300	170
	65	145	124800	134	520	1300	170
	70	147	121160	129	509	1300	170
No. 200	40	134	50880	53	212	920	120
	50	138	45120	47	188	920	120
	60	142	40320	42	168	920	120
	65	143	38400	40	160	920	120
	70	144	34520	37	148	920	120

Dixie Unit Heater No. 800—Model A uses an 850 r.p.m. motor. Ratings on Model A are 25 per cent less than Model B. Three-speed alternating-current motors operate at 500, 850 and 1150 r.p.m.



Rear View Dixie Unit Heater

Air-Way Electric Appliance Corporation

Toledo, Ohio

Unit Heaters for Factories, Shops, Etc.

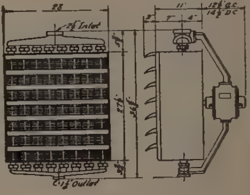
Air-Way
UNIT HEATER

Outstanding features of Air-Way Unit Heaters to which specific attention is invited are: volume of heated air delivered per B.t.u. of fuel consumed; high velocity of air at the outlet, subsequent rapidity and extent of diffusion; exclusive design and construction of unit. Cabinets and louvres are of polished aluminum (which cannot rust or corrode). Unit sections are integrally cast of aluminum alloy. Leakage from water hammering, freezing or galvanic action is impossible. The motor is specially designed and wholly enclosed. The motor frame for 14, 20 and 27 models takes all windings, including 550, 440, 220 and 110 volts; 25, 30, 40, 50 to 60 cycles. They are unconditionally guaranteed.

Capacity Tables

MODEL 27

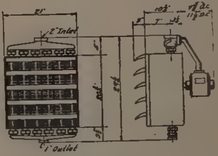
		60 Cycle 1150 r.p.m. Std. Fan 25Cycle 1425 r.p.m. No. 25 Fan Air Delivery 6000 c.f.m. at 70°				60 Cycle 850 r.p.m. Standard Fan Air Delivery 4450 c.f.m. at 70°			
		Intake Air Temperatures				Intake Air Temperatures			
		Zero	50° F.	60° F.	70° F.	Zero	50° F.	60° F.	70° F.
	E.D.R.	1595	1243	1179	1100	1320	1032	978	913
5#	B.t.u.	382700	298500	283200	264000	317000	247500	234500	219000
227°	F.T.	71.5	100	107	112.5	78.5	105.5	111	117
	E.D.R.	2375	2010	1945	1883	1970	1664	1613	1560
100#	B.t.u.	571000	483000	467000	452000	473000	399500	387000	374500
338°	F.T.	106.5	131	137	143	117	139	145	150.5



Model 27

MODEL 20

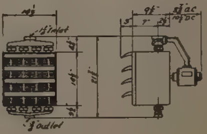
		60 Cycle 1150 r.p.m. Std. Fan 25Cycle 1425 r.p.m. No. 25 Fan Air Delivery 3000 c.f.m. at 70°				60 Cycle 850 r.p.m. Standard Fan Air Delivery 2270 c.f.m. at 70°			
		Intake Air Temperatures				Intake Air Temperatures			
		Zero	50° F.	60° F.	70° F.	Zero	50° F.	60° F.	70° F.
	E.D.R.	853	664	630	588	704	548	521	473
5#	B.t.u.	204500	159600	151200	141300	169000	131800	125000	116600
227°	F.T.	73	101	107.5	113.5	79	105.5	111.5	117.5
	E.D.R.	1270	1075	1038	1005	1048	888	858	830
100#	B.t.u.	305000	258000	249500	241600	252000	213000	206000	199300
338°	F.T.	108	132	138.5	144.5	118	140	145	151



Model 20

MODEL 14

		60 Cycle 1740 r.p.m. Standard Fan Air Delivery 1550 c.f.m. at 70°				60 Cycle 1150 r.p.m. Standard Fan Air Delivery 1020 c.f.m. at 70°			
		Intake Air Temperatures				Intake Air Temperatures			
		Zero	50° F.	60° F.	70° F.	Zero	50° F.	60° F.	70° F.
	E.D.R.	338	263	250	233	258	202	191	179
5#	B.t.u.	81100	63250	60000	56000	62000	48400	45900	42800
227°	F.T.	55.5	89	96.5	103.5	65	95.5	102.5	109
	E.D.R.	504	426	413	399	384	325	315	305
100#	B.t.u.	120900	102200	99000	95800	92300	78200	75600	73200
338°	F.T.	83	113.5	120	127	96.5	124	130	136.5



Model 14

E. D. R.—Equivalent direct radiation, based on one square foot of cast iron radiation when supplied with steam at 5 lb. pressure and exposed in still air at 70 deg., having a heat transmission of 240 B.t.u. per hour.

B.T.U.—Output per hour in British Thermal Units.

F.T.—Average final temperature of air leaving unit in degrees Fahrenheit.

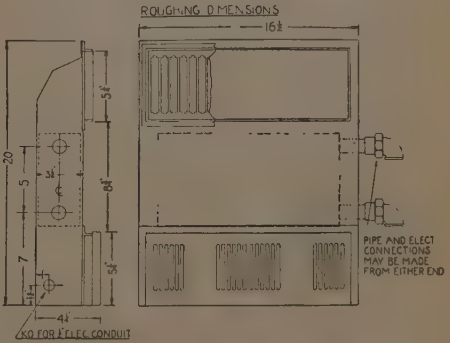
Air-Way
AERIET

The Air-Way Aeriet is a standardized unit assembly designed especially for living rooms, offices and other places where a highly efficient compact heating unit is desired to meet all installation conditions and requirements. This is the only such heating unit now available. The Aeriet may be entirely concealed within partitions, or installed in an attractive cabinet to replace cast iron radiators. It provides positive mechanical movement of air for heating or cooling as may be desired. The heat does not rise along the wall to the ceiling, but is projected out into the room at knee level where it blends with the lower temperatures and rises. There are no valves to regulate. The heating element connected to steam or hot water supply line is integrally cast of non-corrosive alloys, unbreakable and leak-proof. Electric heating elements may also be used exclusively or in combination with steam or hot water sections. A specially designed, **silent,** vibrationless motor operates the blower-type fans. The complete motor assembly is readily accessible by removing two screws from the lower grill.

Model 14 Aeriet is illustrated. This unit has a heating capacity equivalent to 40 sq. ft. of direct radiation and this capacity is achieved with quiet operation at normal fan speeds. Much greater capacity can be produced by running the unit at higher speeds but not silent operation. Various models meet every individual requirement.

Write for more complete information and data.

Side and front elevation views showing dimensions and pipe connections for roughing in Model 14 Aeriet Assembly.



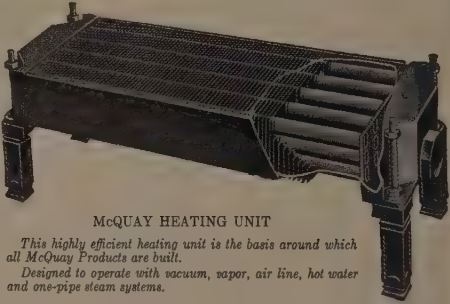
McQUAY RADIATOR CORPORATION

Manufacturers of Cabinet Radiators, Concealed Radiators and Unit Heaters

General Offices
35 E. Wacker Drive, **Chicago, Ill.**
Factory: MINNEAPOLIS, MINN.
Branches In Principal Cities

The McQuay Heating Unit

A distinctive feature of all McQuay products consists of a series of flat, horizontal tubes running the entire length of the heating section and arranged in vertical tiers on one-inch centers. These are held securely in place by copper fins, set perpendicular to the tubes. The entire heating section is nested firmly in bronze metal end tanks or headers that act as manifolds for the entering steam and returning condensation. The specialized arrangement and copper construction of the fins and tubes insure a maximum of heating efficiency.



McQUAY HEATING UNIT

This highly efficient heating unit is the basis around which all McQuay Products are built.

Designed to operate with vacuum, vapor, air line, hot water and one-pipe steam systems.

The shape and design of the tubes preclude the possibility of danger of freezing. The tubes are coated with tin on the inside thereby producing a glass-smooth inner surface, eliminating the hazard of corrosion and clogging or certain destructive chemical reaction.

McQuay Box Type Concealed Radiators

The box type consists of a heavy metal case which is recessed in the wall under a window. The front section has a grille at top for the warm air outlet and at the bottom for entering air. The rear section is shaped slightly concave so as to act as a heat reflector. The heating unit is placed near the bottom; cold air is admitted through a grille at the floor line and passes through this heating unit, rises rapidly in the enclosure, and is precipitated out the grille opening at the top—entirely by convection. Heat is controlled by a damper arrangement located at the top of the cabinet. Front of cabinet is flush with finish wall and similarly decorated.

McQuay Recess Wall Type Concealed Radiators

The recess wall type differs from the box type in that the entire radiator is concealed in the wall, so that only the grille opening, which is flush with the face of the wall, is seen. An opening is left in the baseboard for admitting cold air.

Proper provision is made so that the heating unit is easily accessible.

Recess Wall Type McQuay Radiator

McQuay Cabinet Radiators

An artistically designed cabinet of heavy furniture rust-resisting, copper alloy steel set over a McQuay Heating Unit which is nested inside and near the bottom. Cabinet is furnished primed with one coat of Duco and may be finished to match interior decorations of each apartment or room. Humidification is provided for by means of a water pan which extends the full width of the cabinet and is placed near the top. Design is such that air circulates over the surface of the water as well as under the waterpan.

McQuay Radiators listed here are constructed and designed for vacuum, vapor, air line, one-pipe steam and hot water systems. Tappings are in accordance with Master Steam Fitters' Code as shown above.

Cabinets are factory finished with a priming coat.

"Leg and Stud" Construction

Shipping rate approximately 2 lb. per sq. ft. of radiation.

All radiators are bushed for eccentric return. Allow for this in roughing in.

The published ratings of McQuay Unit Heaters, Heat Cabinets and Bathroom Units are based on data, resulting from actual tests made by competent engineers.

Capacities and Dimensions Intermediate Sizes McQuay Concealed Radiators—Box Type

Series 300 Heating Element Depth....... 3½" Wall Box Depth............. 3¾"					Series 500 Heating Element Depth..... 5¼" Wall Box Depth........... 5½"					Series 700 Heating Element Depth.... 7" Wall Box Depth.......... 7¼"				
Over-all Length of Heating Element, Inches	3½" Deep 21½" High		3½" Deep 24½" High		Over-all Length of Heating Element, Inches	5¼" Deep 21½" High		5¼" Deep 24½" High		Over-all Length of Heating Element, Inches	7" Deep 21½" High		7" Deep 24½" High	
	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.		Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.		Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.
15	301-B	9.0	321-B	9.5	15	501-B	12.5	521-B	13.0	15	701-B	15.0	721-B	15.5
20	303-B	13.0	323-B	13.5	20	503-B	16.0	523-B	17.0	20	703-B	20.0	723-B	21.5
25	305-B	15.5	325-B	16.5	25	505-B	21.0	525-B	22.5	25	705-B	26.0	725-B	28.0
30	307-B	19.0	327-B	20.0	30	507-B	25.0	527-B	26.5	30	707-B	32.5	727-B	34.5
35	309-B	22.5	329-B	24.0	35	509-B	30.0	529-B	32.0	35	709-B	38.5	729-B	40.5
40	311-B	25.5	331-B	27.0	40	511-B	34.5	531-B	36.5	40	711-B	44.5	731-B	47.0
45	313-B	28.5	333-B	30.0	45	513-B	39.0	533-B	42.0	45	713-B	50.5	733-B	53.0
50	315-B	32.0	335-B	33.0	50	515-B	44.0	535-B	46.5	50	715-B	56.5	735-B	59.5
55	317-B	35.5	337-B	37.0	55	517-B	48.0	537-B	51.5	55	717-B	63.0	737-B	66.0
60	319-B	38 0	339-B	40.5	60	519-B	53.0	539-B	56.5	60	719-B	68.5	739-B	72.0

McQuay Cabinet Radiator (Bathroom Type)

A plain design of cabinet, without humidifier, which sets over a McQuay Heating Element. When finished to blend with bathroom scheme it is inconspicuous. This, together with the small dimensions, makes this type also equally desirable for kitchenettes, small offices, etc.—wherever space must be conserved.

Series 900 Heating Element Depth... 8¾" Wall Box Depth.......... 9"				
Over-all Length of Heating Element, Inches	8¾" Deep 21½" High		8¾" Deep 24½" High	
	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.
15	901-B	16.5	921-B	17.5
20	903-B	22.5	923-B	24.0
25	905-B	29.5	925-B	31.5
30	907-B	37.0	927-B	39.5
35	909-B	44.0	929-B	46.0
40	911-B	50.0	931-B	53.0
45	913-B	58.0	933-B	61.0
50	915-B	65.5	935-B	68.5
55	917-B	72.5	937-B	75.5
60	919-B	80.0	939-B	83.0

DIMENSIONS AND CAPACITIES McQUAY CABINET RADIATORS

Series 500-A—All Cabinets in This Series Are 5¼ in. in Depth

Over-all Length of Radiator in Inches	5¼" Deep 20" High		5¼" Deep 23" High		5¼" Deep 26" High		5¼" Deep 32" High		5¼" Deep 38" High	
	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.
15	501-A	12.5	521-A	13.0	541-A	13.5	561-A	15.0	581-A	16.0
17½	502-A	14.0	522-A	14.5	542-A	15.5	562-A	17.5	582-A	19.5
20	503-A	16.0	523-A	17.0	543-A	18.5	563-A	20.5	583-A	22.5
22½	504-A	18.5	524-A	19.5	544-A	21.0	564-A	23.5	584-A	25.5
25	505-A	21.0	525-A	22.0	545-A	24.5	565-A	26.0	585-A	29.0
27½	506-A	23.0	526-A	24.5	546-A	26.0	566-A	29.0	586-A	32.5
30	507-A	25.0	527-A	26.5	547-A	29.0	567-A	32.0	587-A	35.5
32½	508-A	27.5	528-A	29.0	548-A	31.5	568-A	35.0	588-A	39.0
35	509-A	30.0	529-A	31.5	549-A	34.0	569-A	38.0	589-A	42.0
37½	510-A	32.5	530-A	34.0	550-A	36.5	570-A	41.0	590-A	45.0
40	511-A	35.0	531-A	36.5	551-A	39.0	571-A	43.5	591-A	48.0
42½	512-A	37.0	532-A	39.0	552-A	41.5	572-A	46.5	592-A	51.0
45	513-A	39.0	533-A	41.5	553-A	44.5	573-A	49.5	593-A	54.0
47½	514-A	41.5	534-A	44.0	554-A	47.5	574-A	52.5	594-A	57.0
50	515-A	43.5	535-A	46.5	555-A	50.0	575-A	55.5	595-A	60.5
52½	516-A	46.0	536-A	49.0	556-A	52.5	576-A	58.5	596-A	63.5
55	517-A	48.0	537-A	51.5	557-A	55.0	577-A	61.5	597-A	67.0
57½	518-A	50.5	538-A	54.0	558-A	58.0	578-A	64.0	598-A	70.0
60	519-A	52.5	539-A	56.5	559-A	60.5	579-A	67.5	599-A	73.0
62½	520-A	55.0	540-A	59.0	560-A	63.0	580-A	70.5	600-A	76.5

Series 900-A—All Cabinets in This Series Are 8¾ in. in Depth

Over-all Length of Radiator in Inches	8¾" Deep 20" High		8¾" Deep 23" High		8¾" Deep 26" High		8¾" Deep 32" High		8¾" Deep 38" High	
	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.
15	901-A	17.0	921-A	18.0	941-A	19.0	961-A	21.5	981-A	24.0
17½	902-A	20.5	922-A	21.5	942-A	22.5	962-A	25.0	982-A	28.0
20	903-A	23.0	923-A	24.5	943-A	26.0	963-A	29.5	983-A	33.0
22½	904-A	26.5	924-A	28.5	944-A	30.0	964-A	33.5	984-A	37.5
25	905-A	31.0	925-A	32.5	945-A	34.0	965-A	38.0	985-A	42.0
27½	906-A	34.0	926-A	36.0	946-A	38.0	966-A	42.5	986-A	46.5
30	907-A	38.0	927-A	40.0	947-A	42.0	967-A	46.5	987-A	51.5
32½	908-A	41.5	928-A	43.5	948-A	46.0	968-A	51.0	988-A	56.0
35	909-A	45.0	929-A	47.5	949-A	50.0	969-A	55.0	989-A	60.5
37½	910-A	48.5	930-A	51.5	950-A	54.0	970-A	59.5	990-A	65.0
40	911-A	52.0	931-A	55.5	951-A	58.0	971-A	64.0	991-A	70.0
42½	912-A	56.5	932-A	59.0	952-A	62.0	972-A	68.0	992-A	74.5
45	913-A	60.0	933-A	62.5	953-A	66.0	973-A	72.0	993-A	79.0
47½	914-A	63.5	934-A	66.5	954-A	70.0	974-A	76.0	994-A	83.5
50	915-A	67.5	935-A	70.5	955-A	73.5	975-A	81.0	995-A	88.5
52½	916-A	71.0	936-A	74.0	956-A	77.5	976-A	84.5	996-A	93.0
55	917-A	74.5	937-A	78.0	957-A	81.5	977-A	88.5	997-A	97.5
57½	918-A	78.0	938-A	82.0	958-A	85.5	978-A	93.0	998-A	102.0
60	919-A	81.5	939-A	85.5	959-A	89.5	979-A	97.5	999-A	106.5
62½	920-A	85.5	940-A	89.5	960-A	93.0	980-A	101.5	1000-A	111.0

Series 700-A—All Cabinets in This Series Are 7 in. in Depth

Over-all Length of Radiator in Inches	7" Deep 20" High		7" Deep 23" High		7" Deep 26" High		7" Deep 32" High		7" Deep 38" High	
	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.
15	701-A	15.0	721-A	15.5	741-A	16.5	761-A	18.5	781-A	20.5
17½	702-A	17.0	722-A	18.5	742-A	20.0	762-A	22.0	782-A	24.5
20	703-A	20.0	723-A	21.5	743-A	23.0	763-A	25.5	783-A	29.0
22½	704-A	23.0	724-A	24.5	744-A	26.0	764-A	29.5	784-A	33.0
25	705-A	26.0	725-A	28.0	745-A	29.5	765-A	33.0	785-A	36.5
27½	706-A	29.0	726-A	31.0	746-A	33.0	766-A	36.5	786-A	41.0
30	707-A	32.5	727-A	34.0	747-A	36.5	767-A	40.0	787-A	45.0
32½	708-A	35.5	728-A	37.0	748-A	39.5	768-A	43.5	788-A	49.5
35	709-A	38.5	729-A	40.5	749-A	42.5	769-A	47.5	789-A	53.0
37½	710-A	41.5	730-A	43.5	750-A	46.0	770-A	51.5	790-A	57.0
40	711-A	44.5	731-A	47.0	751-A	49.5	771-A	55.0	791-A	61.0
42½	712-A	47.5	732-A	50.0	752-A	53.0	772-A	58.5	792-A	65.0
45	713-A	50.5	733-A	53.0	753-A	56.0	773-A	62.0	793-A	69.5
47½	714-A	53.5	734-A	56.0	754-A	59.0	774-A	65.5	794-A	73.0
50	715-A	56.5	735-A	59.0	755-A	62.5	775-A	69.5	795-A	77.5
52½	716-A	59.5	736-A	62.5	756-A	66.5	776-A	73.0	796-A	81.5
55	717-A	62.5	737-A	66.0	757-A	69.5	777-A	77.0	797-A	85.0
57½	718-A	66.0	738-A	69.0	758-A	72.5	778-A	80.5	798-A	89.0
60	719-A	68.5	739-A	72.0	759-A	76.0	779-A	84.0	799-A	93.0

Series 1100-A—All Cabinets in This Series Are 10½ in. in Depth

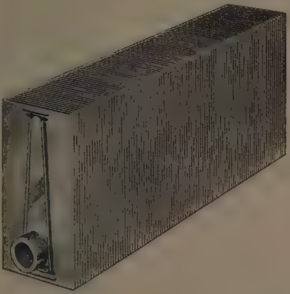
Over-all Length of Radiator in Inches	10½" Deep 20" High		10½" Deep 23" High		10½" Deep 26" High		10½" Deep 32" High		10½" Deep 38" High	
	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.	Stock No.	Sq. Ft. Rad.
15	1101-A	19.5	1121-A	20.5	1141-A	21.0	1161-A	24.0	1181-A	26.5
17½	1102-A	22.5	1122-A	24.0	1142-A	24.5	1162-A	28.5	1182-A	31.5
20	1103-A	35.5	1123-A	27.5	1143-A	29.5	1163-A	33.5	1183-A	37.0
22½	1104-A	30.0	1124-A	32.0	1144-A	34.0	1164-A	38.0	1184-A	43.0
25	1105-A	34.5	1125-A	36.5	1145-A	38.5	1165-A	43.0	1185-A	48.5
27½	1106-A	38.5	1126-A	40.5	1146-A	43.0	1166-A	48.0	1186-A	54.0
30	1107-A	43.0	1127-A	45.0	1147-A	47.5	1167-A	52.5	1187-A	59.5
32½	1108-A	47.5	1128-A	49.5	1148-A	52.0	1168-A	57.5	1188-A	64.5
35	1109-A	51.5	1129-A	53.5	1149-A	56.5	1169-A	62.5	1189-A	70.0
37½	1110-A	55.5	1130-A	58.0	1150-A	61.0	1170-A	67.0	1190-A	75.0
40	1111-A	60.0	1131-A	62.5	1151-A	65.5	1171-A	72.0	1191-A	80.5
42½	1112-A	64.0	1132-A	67.0	1152-A	70.0	1172-A	77.0	1192-A	85.5
45	1113-A	68.5	1133-A	71.0	1153-A	74.0	1173-A	81.5	1193-A	91.0
47½	1114-A	72.5	1134-A	75.5	1154-A	78.5	1174-A	86.0	1194-A	96.5
50	1115-A	77.0	1135-A	80.0	1155-A	83.0	1175-A	91.0	1195-A	101.5
52½	1116-A	81.0	1136-A	84.5	1156-A	87.5	1176-A	95.5	1196-A	106.5
55	1117-A	85.5	1137-A	89.0	1157-A	92.0	1177-A	100.5	1197-A	111.5
57½	1118-A	90.0	1138-A	93.0	1158-A	96.5	1178-A	105.5	1198-A	117.0
60	1119-A	94.0	1139-A	97.5	1159-A	101.0	1179-A	110.0	1199-A	122.5

The Herman Nelson Corporation

Moline, Illinois

Manufacturers of

Herman Nelson hiJet Heaters; Herman Nelson Invisible Radiators; Univent Ventilation; Herman Nelson Radiator Sections; Silentvent Exhausters

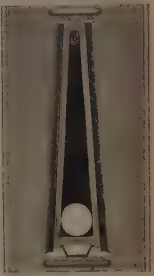


The Herman Nelson Radiator has proven its worth as a practical means for air warming, air cooling, air condensing, air drying, etc., as demonstrated by the many installations in these various applications.

The radiator consists of a steamway or core upon which smooth, flat surface plates are firmly wedged in parallel, causing a tight metal to metal contact. As the core or steamway is cast of a special homogeneous metal in one piece, the liability of leakage is eliminated. It is leak-proof and rust-proof, and has no joints of any kind. It provides a construction that will withstand expansion and water hammer strains without injury.

The core extends the entire length of the radiator and is tapered in cross section having an average thickness 1 in. and a 4½ per cent taper. The core is 6⅝ in. wide and the walls which are $\frac{5}{32}$ in. thick are provided with stays through the middle on 4 in. centers.

The radiators are regularly tested to a hydrostatic pressure of 250 lb. and sections are selected at random from stock for a test of 500 lb. hydrostatic pressure. Operating pressures are guaranteed up to 150 lb.

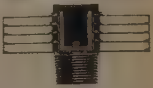


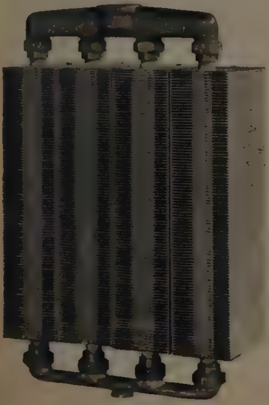
Dimensions

Herman Nelson Radiator Sections can be assembled in combinations to meet almost any requirement and may be used either vertically or horizontally. They are made up in sections 10 in., 14 in., 20 in., 30 in., 40 in. and 50 in. in length with four different plate spacings and the stubs are threaded for 1 in. pipe connections.

Supply and return manifolds will be furnished by the manufacturers for assemblies consisting of 2, 3, 4, 5 and 6 sections.

Where hot water or other liquids are circulated through the radiator, and the latter is used horizontally, it will be necessary to use vents which are located in the center of the section.





Light Weight and Portable

Due to the comparatively light weight of Herman Nelson Radiator Sections, they may be supported from the supply pipe headers—but where a large number of sections are so carried, adequate provision should be made for supporting the pipe lines. The weights vary somewhat, depending upon the spacing and size of the sections, but if an allowance of 31 lb. per square foot of face area in the block is allowed for each row, it will be sufficient to enable the proper determination of piping supports.

The Herman Nelson Corporation's Engineering Department will appreciate an opportunity to cooperate on any problems involving this radiator.

HERMAN NELSON
hiJet
HEATER

Rear View Model 80 hiJet Heater

This product is manufactured in three (3) sizes, referred to as Nos. 42, 80 and 180. The heating element in the hiJet Heater is the Herman Nelson leak-proof, jointless radiator.

Operating steam pressures up to 150 lb.

A long range projection of warm air to working level is provided.

The Her-Nel-Co motor furnished as standard equipment.

For description of the radiator see opposite page.

Light Weight Compact Portable

Heaters Nos. 42 and 80 completely assembled, weigh approximately 92 and 170 lb. respectively. They are often hung on pipe lines thus reducing installation cost. The No. 180, largest of the line, weighs approximately 350 lb. and may be easily supported or moved.

Motors

Herman Nelson hiJet Heaters are powered by Her-Nel-Co motors. Due to its lowered power cost, wider range of speeds and greater efficiency, the Her-Nel-Co motor is ideally fitted for hiJet Heater service.

Motors furnished regularly for two speed operation. Variable speed operation may be obtained through central control. These motors may be furnished for a standard voltage direct or alternating current, single phase or polyphase.

Fans

Fans for all three models are of the propeller type. They have been developed to provide high efficiency, great air projection and the least noise, without sacrificing results.

The sheet aluminum blades are riveted onto a rigid steel spider, balanced after assembly and tested at full speed in the unit before shipping.

Capacities

The following schedule gives the capacities of the three models in equivalent direct radiation, entering air temperature 60 deg. with 2 lb. steam pressure.

	Model		
	42	80	180
Full Speed	260	485	1040
Slow Speed	185	348	750

Front View Model 80 hiJet Heater

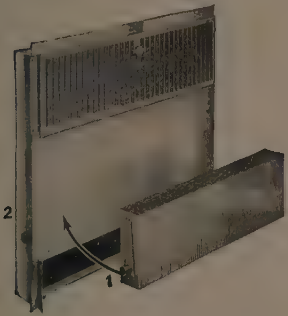
For catalog and more detailed information address

The Herman Nelson Corporation, Moline, Illinois.

HERMAN
NELSON
Invisible
RADIATOR

The Herman Nelson Invisible Radiator may be used for either steam, vapor, vacuum or hot water heating service.

It consists of a substantial steel case indicated by Fig. 2, which encloses the heating element; a heat control damper, and an attractive heat outlet grille. The heating element, or Herman Nelson Radiator is indicated by Fig. 1.



The complete unit is shipped ready for installation within any standard wall or partition.

The operation of the Herman Nelson Invisible Radiator is very simple and positive. The air from the room enters the inlet at the floor, is warmed by passing through the heating element, and is emitted into the room through the heat outlet grille at the top.

The damper method of heat control has been adopted as preferable to valve control because of its simplicity. Heat output may be controlled by moving the damper to any position between open and closed. The damper is operated by a small knob shown on the face of the grille.

Installation

The installation of Herman Nelson Invisible Radiators is quite simple. After the opening has been provided in the walls by the general contractor, it is only necessary for the heating contractor to slip the complete unit in place, fasten it, make the simple pipe connections required, and then the radiator is ready for metal lath and plaster by other contractors.

Dimensions

For the sake of brevity, the following table is prepared to indicate the height, length and width of standard stock radiators regularly furnished:

Width	Height	Length
Narrow (for 3⅝" recess) Medium (for 4⅞" recess) Wide (for 7½" recess)	20" 24" 30"	10" 14" 20" 30" 40" 50"

Cutaway section showing complete radiator behind plastered wall.

Radiators of other dimensions are built special and furnished at additional cost.

The Herman Nelson Invisible Radiator catalog will be gladly furnished to those interested, upon request.

UNIVENT

(TRADE MARK)

VENTILATION

Manufactured by the Herman Nelson Corporation

Because the Univent is sold as a system to deliver a certain predetermined result in Ventilation, instead of so many pieces of mechanical equipment, space in The Guide does not permit of more than a general description of the simplicity, accessibility, and a few of the outstanding features of the machine itself. Engineers interested in complete detailed information will be furnished our Architects' and Engineers' catalog upon request.

Univent Ventilation is a mechanical system of ventilation wherein outside air is taken directly from outside the wall or window, cleaned, warmed to a comfortable temperature, and diffused to every nook and corner of a room, noiselessly and without drafts.

Description of the Univent

The cabinet, illustrated, enclosing the mechanical equipment of the Univent, is built of pleasing proportion and constructed of high grade furniture steel.

The base of the cabinet is seamless and copper plated, and is a complete protection from rust, corrosion and deterioration.

The fan and motor are a complete unit specially mounted on the base to insure noiseless operation. They are easily removable for cleaning or attention.

The air filter is easily removable for cleaning.

The radiator used in the Univent is the Herman Nelson Radiator previously described. It has sufficient capacity for warming incoming air from 40 deg. below zero to 70 deg., or from zero to 110 deg. The radiator is so arranged that it can be connected to any steam or vapor heating plant. It may be furnished for hot water application on special order.

Above the radiator is the warm air damper and compensating damper which may be operated by hand or automatically, for the control of the temperature of the air as it leaves the Univent.

Models

There are three standard models of Univents: "S," "SD" and "R," which provide for bringing in of air through wall intake.

There are also three (3) window intake models: "O," "W" and "WR," for use in buildings where it is impossible to bring fresh air intake through the wall at a lower level.

Univent Fan and Motor

The Univent is equipped with a large, single, low speed, aluminum fan, requiring no housing. The fan is powered with a specially designed Her-Nel-Co motor, highly efficient, quiet, simple and dependable. Her-Nel-Co motors may be made in either the direct or alternating current type as desired.

Automatic Temperature Control

Any well known system of Automatic Temperature Control may be used with the Univent System and can be easily installed at erection or any future date.

John J. Nesbitt, Inc.

Executive Offices and Factory
State Road and Rhawn Street, **Holmesburg, Philadelphia**

Branch Office, 11 Park Place, New York

Sales and Service Through Offices of the American Blower Corp.
In all the Principal Cities of the United States

PRODUCTS

1: Universal Heating and Ventilating Unit for SCHOOL ROOMS.

2: Universal Unit Heaters for LARGE ROOMS like Banking Rooms, Show Rooms, Stores, Sales Rooms, Offices, Assemblies, Churches, etc.

3: Universal Concealed and Cabinet Heaters for HOMES.

.1.

Universal Heating and Ventilating Unit for SCHOOL ROOMS

"Universal" has always been at the forefront in the use and development of the features that have made the Unit system universally accepted as ideal for schoolroom heating and ventilating. Among many other major improvements, the Universal Unit introduced the light weight heater, the present-day form of unit with motor and fan assembly in base of cabinet, alternating current motors with rigid metal to metal mounting and the successful use of the blast system whereby direct radiation is eliminated from the class room.

"Universal" Multifin Copper Tube Radiator

Standard Universal Units are supplied with horizontal seamless copper tube radiators, the ends of the tubes of which are connected to cast iron headers by means of ground joints, thus being free of soldered, braised, welded or packed joints. Over these tubes are hydraulically pressed thin copper plates or fins, thus insuring real thermal contact between tubes and plates, making a highly efficient heating unit. Tested at 125 pound working pressure, and will stand freezing without breaking.

Motor

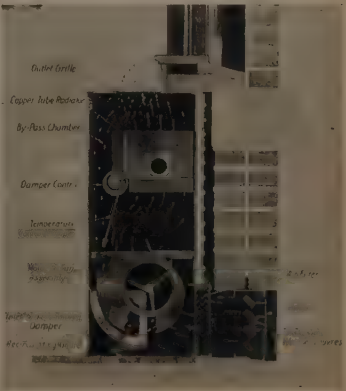
The motor of the "Universal" Unit is supplied for quiet operation on any character of current. The use of a motor generator set is no longer necessary with this system, but will be furnished upon request.

Three Point Lead Mounting

The Motor and Fan assembly of the Universal Unit is mounted in the cabinet on three steel ball points in contact with lead liners, making a very quiet operating unit, with no electrical noises. It has also made practical the use of alternating current motors with a permanent and rigid supporting device.

Fans

Universal fans are of the Sirocco type, multiblade, low speed, double inlet, designed to operate at 720 r.p.m. plus or minus 5 per cent. No greater efficiency known. The by-pass chamber is parallel to heating chamber and so located as to



guide the column of cool air across the currents of warm air when mixing—thus creating an absolutely vertical discharge—and guide the cool air away from room occupants when completely by-passing. The large space between the fan and the radiator results in the uniform distribution and heating of entire air volume.

Thermostatic Control Optional

All Universal Units can be equipped with thermostatic and pneumatic attachments for pneumatic control of the inlet damper and thermostatic control of the by-pass damper. This equipment is optional.

Sizes and Capacities

Universal Unit Heating and Ventilating Cabinets for schools are obtainable in six sizes of cabinets, with six different air deliveries. Two different radiator sizes are available for each cabinet size. Thru the operation of the volume regulators, it is possible to obtain any delivery between the minimum of 450 c.f.m. and the maximum of 1500 c.f.m.

Refer to table of Capacities and Dimensions on pages 22 and 23 of the "Universal Heating & Ventilating Unit," publication No. 210—(A. I. A. File No. 30-d-11) for complete information. Send for this publication—as well as our Catalogue and Engineers Data Book.

.2.

Universal Unit Heaters for LARGE ROOMS

and beautiful interiors like Banking Rooms, Show Rooms, Stores, Offices, Assemblies, Churches, etc.

The Universal Unit Heater maintains a uniform temperature in the room—ceiling and floor alike—and it does this to the satisfaction of the heating engineer. It is also sufficiently attractive to meet the exacting requirements of the architect, and so quiet in operation as not to annoy those in the room.

Universal Unit Heaters are made on the same principles that have made the Universal Heating and Ventilating Unit for Schools so popular during the past 16 years. In them you will find the same high velocity vertical discharge, the same highly efficient Universal Multifin Copper Tube Radiator with its ground joint connections and its extra strength for more than working pressures and ability to stand up under freezing without breaking.

You will find the same low speed, long life, trouble free motor—either alternating or direct current—with the three point suspension of motor and fan on lead liners, making an assembly almost entirely free from operating noises.

You will find the same Sirocco type aluminum multiblade low speed double inlet fan. You will find the same volume regulators on the outlet of the fan housing so the air delivery of the Unit can be regulated to the requirements of the room.

ADVANTAGES
of Universal Unit Heaters

Attractive in Appearance: Encased in a beautiful Cabinet of heavy high grade furniture stock steel.

Larger Heating Capacity in Smaller Space: Universal Unit Heaters with five times the heating capacity require but one-fifth the space taken up by direct radiators and can often be entirely concealed. This is especially important in centers of high rent where the best use must be made of all space.

Tremendous Saving in Fuel: High velocity heat diffusion from the vertical discharge results in uniform temperature over entire area, with only slight difference between floor and ceiling, effecting a tremendous saving in fuel by eliminating overheating of upper areas.

Quick Heating of Large Areas: Rapid circulation of air by low speed motor driven fans over a high efficiency copper tube radiator results in quick heating of

Typical installation in a Sales Room, where every inch of spac is valuable, the Universal Unit *takes less space and is more efficient.*

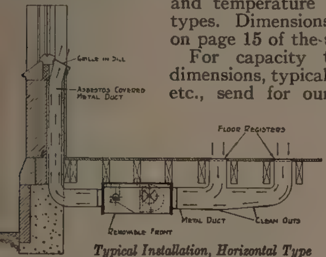
ge areas—a vital matter in the heating of churches d assembly rooms.

Temperature Control: Simple and effective conol of room temperature by means of making and eaking electric contact in line to motor.

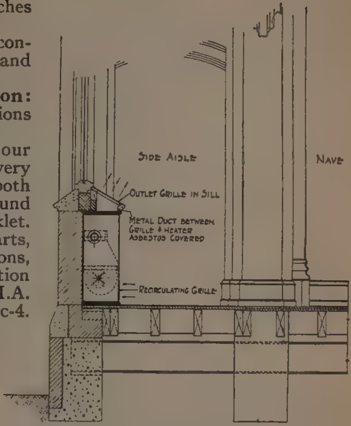
Less Expensive to Install than Direct Radiation: ping system simplified and number of connections duced, effecting a saving in labor and material.

Sizes of Heaters: The charts on page 14 of our ablication No. 209 give the heating capacity, air delivery and temperature rise for both types. Dimensions will be found on page 15 of the same booklet.

For capacity these charts, dimensions, typical installations, etc., send for our Publication # 209, A.I.A. File # 30-c-4.



Typical Installation, Horizontal Type
Universal Unit Heater



Detail from transverse section of Church showing typical Universal Unit *Installation.*

.3.

iversal Concealed and Cabinet Heaters

FOR HOMES

With the Universal cabinet heater, the temrature of the floor is practically the same as the ceiling—an impossibility with cast iron diation. With cast iron radiators, temperares are always considerably gher at the ceiling than the floor. oor temperatures are seldom isfactory, as the proper temrature is usually maintained for body comfort at about the height of a chair, leaving the floor chilly, uncomfortable and often a frequent cause of colds and sickness. The Universal Cabinet Heater corrects this condition.

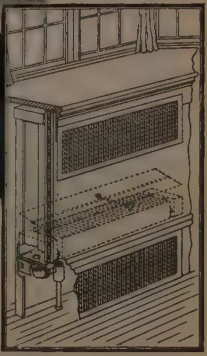
Cleanest Form of Heating for Homes: The Universal cabinet heater discharges the heat outward and into the room, instead of against walls and ceilings, as with direct radiation. This prevents the dirt streaks and soiled draperies so prevalent with direct radiation.

binet Heater Dimensions and Capacities

W 4½ in.			W 6½ in.		
uivalent ast Iron Direct diation q Ft.	H	L	Equivalent Cast Iron Direct Radiation Sq. Ft.	H	L
13	20″	29″	18	20″	29″
20	20″	45″	30	20″	45″
25	20″	55″	40	20″	55″
17	26″	29″	25	26″	29″
24	26″	45″	40	26″	45″
29	26″	55″	45	26″	55″
20	36″	29″	33	36″	29″
30	36″	45″	50	36″	45″
40	36″	55″	60	36″	55″
W 8½ in.			W 9½ n.		
20	20″	29″	25	20″	29″
35	20″	45″	40	20″	45″
45	20″	55″	50	20″	55″
27	26″	29″	34	26″	29″
48	26″	45″	54	26″	45″
60	26″	55″	67	26″	55″
37	36″	29″	41	36″	29″
58	36″	45″	65	36″	45″
70	36″	55″	80	36″	55″

Showing the Universal Heater *concealed below the window. See next page for the Cabinet Type of Heater.*

The Radiator can be installed or removed after the cabinet is sealed in the wall.



Six of the 27 different Cabinet sizes of Universal *Concealed and Cabinet Heaters.*

15 *Advantages of* Universal Cabinet and Concealed Heaters

1. A combination of beauty with utility.
2. Can be painted or decorated to harmonize with furnishings and color schemes.
3. Efficient in performance.
4. Economical in operation.
5. Diffuses heat thoroughly.
6. Creates uniform temperature—ceiling and floor alike.
7. Leaves no cold spots in room.
8. Control of temperature positive and immediate.
9. Cleanest known form of heating.
10. Outward discharge prevents discoloration of walls, ceilings and draperies.
11. Requires considerably less space than cast iron radiation.
12. Can be installed without a change in design of the old heating system.
13. The entire front of the cabinet heater can easily be removed by housewife or maid for cleaning.
14. May be entirely concealed in wall if desired.
15. When concealed in wall, *the radiator is accessible.*

CONCEALED HEATER—Dimensions and Capacities

Stack Height Floor to Bottom of Grille Inches	W 4½ in.						W 6½ in.					
	Equivalent Cast Iron Direct Radiation Sq. Ft.	"L" Length Overall	Equivalent Cast Iron Direct Radiation Sq. Ft.	"L" Length Overall	Equivalent Cast Iron Direct Radiation Sq. Ft.	"L" Length Overall	Equivalent Cast Iron Direct Radiation Sq. Ft.	"L" Length Overall	Equivalent Cast Iron Direct Radiation Sq. Ft.	"L" Length Overall	Equivalent Cast Iron Direct Radiation Sq. Ft.	"L" Length Overall
10	15	29	17	45	30	55	20	29	25	45	48	55
15	16	29	20	45	32	55	22	29	28	45	51	55
20	17½	29	23	45	35	55	25	29	32	45	54	55
25	19	29	26	45	37	55	29	29	36	45	57	55
30	20	29	28	45	40	55	32	29	40	45	60	55
35	22	29	30	45	43	55	36	29	43	45	63	55
40	23	29	33	45	45	55	38	29	47	45	66	55
45	25	29	36	45	48	55	41	29	51	45	69	55
50	26	29	39	45	50	55	43	29	54	45	72	55
55	28	29	42	45	53	55	46	29	57	45	75	55
60	29	29	45	45	55	55	48	29	60	45	78	55
65	31	29	48	45	58	55	51	29	63	45	81	55
70	33	29	50	45	60	55	53	29	65	45	84	55
75	34	29	52	45	63	55	57	29	68	45	87	55
80	36	29	55	45	65	55	59	29	71	45	90	55
85	37	29	58	45	68	55	62	29	74	45	93	55

C=½ of W: example W4½ C=2¼ in. O=Stack Height floor to bottom of grille as given below plus 7 in.

Peerless Unit Ventilation Company, Inc.

Heating and Ventilating Systems -:- Industrial Heating Units

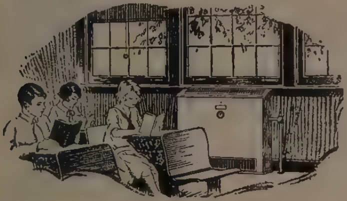
Bridgeport, Connecticut

Sales Representatives from Coast to Coast

Products

"PEERVENT" and "PEERLESS" HEATING and VENTILATING UNITS, for Schools, Hospitals, Libraries, Churches, Dormitories, Club Rooms, Theaters, Banks, Offices, Auditoriums and other Buildings where many people congregate.

"PEERLESS" INDUSTRIAL HEATING UNITS (used in place of cast iron radiators), for Factories, Garages and other Industrial Buildings.



"PeerVent" and "Peerless" Heating-Ventilating Units

This Company makes two types of heating and ventilating units—"PEERVENT" and "PEERLESS"—both intended for the same service but differing in design and construction. Only the PEERVENT Unit is illustrated in these pages. Information about PEERLESS Units will be sent on request.

Features of the Improved "PeerVent" Unit

The PEERVENT Unit of today has many important improvements, including the new PeerFin radiator. This radiator consists of two large copper alloy tubes, each surrounded by a series of closely spaced fins, also of copper alloy. The fins are embedded tightly into the tubes, so that under any conditions of expansion and contraction the fins and tubes are in perfect contact and there can be no loss of efficiency in the transfer of heat from tube to fin. The tubes are expanded into malleable iron headers, in the same manner that boiler tubes are expanded into the tube sheets, and the radiator assembly does not contain a single soldered, welded, brazed or gasketed joint. Test pressure, 150 lb.; operating pressure, 100 lb.

Another improvement in the new PEERVENT Unit is the noiseless alternating current motor. This motor is of a design which has been developed after years of research and experimentation. It is mounted by means of a specially designed spring suspension, which precludes the possibility of noise caused by the transmission of phase vibrations. This motor is equipped with an auto-transformer, an integral part of the motor, for providing speed regulation within limits as close as obtainable with direct current motors. This feature saves power, as less current is consumed at low speeds.

THE new PEERVENT motor improvements are the final step in placing the unit system on a strictly unit basis. The motor-generator outfit is eliminated. The unit motors operate independently and there is no expense for current except for the unit or units that are actually in service. A single room can be ventilated without the operation of any apparatus other than the PEERVENT Unit. There is also a considerable saving in the elimination of the first cost and operating cost of the motor-generator equipment.

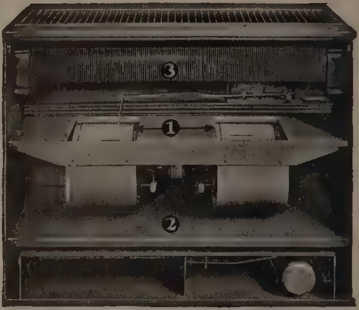
PeerVent Heating and Ventilating Unit

Other improvements in the new PEERVENT Unit include a single-leaf damper which takes the place of the former interconnected fresh air and recirculation dampers, eliminating mechanical linkage. There are no mid-way positions of this damper: either the full volume of fresh air enters the unit or there is a complete recirculation of the air in the room. This damper, as well as the mixing damper, has been provided with improved bearings. The mixing damper can be equipped with any type of automatic temperature control.

New fan housings have been designed, providing larger discharge capacity at considerably lower tip speeds.

The mixing damper, radiator, motor and fan assembly, base assembly and air filter are all easily removable without the use of tools. The air filter, which is not included as part of the unit equipment, can be of any make preferred and can be installed after the unit has been erected, without any changes in the unit. The filter rests upon supports below the motor and fan assembly, sliding in and out of the unit like the drawer of a desk. With the filter in this position the air is cleaned before it reaches the fans, radiator, etc., and the dirt therefore does not reach these parts.

The new PEERVENT Unit can be equipped with a positive-action PeerTherm Control, which automatically prevents the intake of cold air at any time when the room temperature falls below 65 deg. (or any other predetermined temperature within a range of 15 deg.)

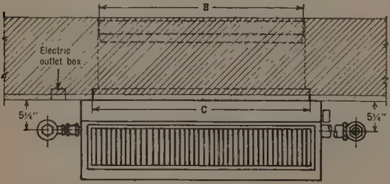


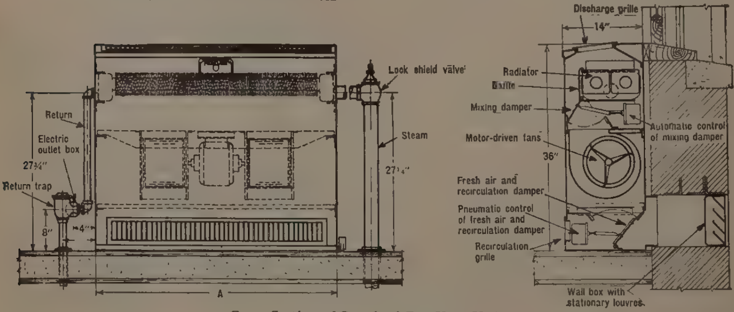
PeerVent Heating and Ventilating Unit with front removed to show interior parts. The fan housings (1) have been improved to provide greater discharge capacity at lower speeds. The air filter (2) is extra equipment, not included with the Unit, and can be of any make specified. The new PeerFin Radiator (3) is an important improvement. This view shows only one of the two rows of closely-spaced fins (see cross-section below).

Four types of PEERVENT Units have now been standardized, and one or another of them will meet practically any architectural requirements, including installations in existing buildings. Six different types of control have also been standardized, including automatic control throughout, hand control throughout, and various combinations of hand and automatic regulation.

Catalogues

Catalogues of PEERVENT Heating and Ventilating Units and PEERLESS Industrial Unit Heaters will be sent on request.





Cross Section of Standard PeerVent Unit

Engineering Data—PEERVENT Heating and Ventilating Units

Unit Number	Maximum Number of Pupils	Volume Cubic Feet per Minute	Entering Air −20°				Entering Air −10°				Entering Air 0°				Entering Air +10°			
			Total Capacity E.D.R.	Excess Capacity E.D.R.	Final Temperature	Condensation Pounds per Hour	Total Capacity E.D.R.	Excess Capacity E.D.R.	Final Temperature	Condensation Pounds per Hour	Total Capacity E.D.R.	Excess Capacity E.D.R.	Final Temperature	Condensation Pounds per Hour	Total Capacity E.D.R.	Excess Capacity E.D.R.	Final Temperature	Condensation Pounds per Hour
3624	15	450	251	48	85	63	239	52	90	60	218	57	95	54	206	72	102	51
	20	600	326	39	82	81	299	50	86	75	275	61	90	69	260	81	97	65
	25	750	395	36	79	99	355	40	81	89	329	58	85	82	307	82	92	77
3633	25	750	427	75	87	107	396	91	90	99	372	110	97	93	345	125	102	86
	30	900	496	72	83	124	453	87	87	113	415	102	91	104	387	123	96	97
	35	1050	553	50	79	138	508	71	83	127	455	80	85	114	418	105	90	105
3642	35	1050	582	100	84	145	547	118	86	137	502	135	94	125	473	165	100	118
	40	1200	638	94	80	159	580	91	83	145	548	113	90	137	508	153	96	127
	45	1350	682	42	76	170	635	86	81	159	595	113	87	149	555	153	93	139
3651	45	1350	761	125	86	190	702	150	90	175	646	175	94	161	608	212	100	152
	50	1500	797	77	80	199	727	102	83	182	686	153	90	171	638	197	95	159
	55	1650	828	35	74	207	743	60	77	186	720	134	86	180	653	163	90	138

Heating Capacities are expressed in square feet of equivalent direct radiation (E.D.R.) To express these capacities in B.t.u. per hour, multiply E.D.R. by 240.

Volume of Air is expressed in cubic feet per minute (C.F.M.)

Unit Number	Maximum Number of Pupils	Volume Cubic Feet per Minute	Entering Air +20°				Dimensions Height...36" Depth...14"		Approximate Shipping Weight Pounds	Power Consumption in Watts	PIPING DATA				
											Steam&Return, 5¼" from Unit Back				
												Steam Size (see note)		Return Size (see note)	
			Total Capacity E.D.R.	Excess Capacity E.D.R.	Final Temperature	Condensation Pounds per Hour	Length Overall Outside L	Fresh Air Intake 8½" x B B			Height Steam and Return from Floor	Gravity System	Vacuum System	Gravity System	Vacuum System
3624	15	450	193	83	108	48	24⅜"	18½"	250	70	27¾"	1½"	1¼"	1"	¾"
	20	600	243	97	103	61	24⅜"	18½"	250	84	27¾"	1½"	1¼"	1"	¾"
	25	750	285	102	98	71	24⅜"	18½"	250	98	27¾"	1½"	1¼"	1"	¾"
3633	25	750	324	144	109	81	33⅜"	27½"	300	112	27¾"	1½"	1¼"	1"	¾"
	30	900	367	150	104	92	33⅜"	27½"	300	126	27¾"	2"	1½"	1"	¾"
	35	1050	405	150	99	101	33⅜"	27½"	300	146	27¾"	2"	1½"	1"	¾"
3642	35	1050	448	196	108	112	42⅜"	36½"	350	141	27¾"	2"	2"	1"	¾"
	40	1200	489	201	104	121	42⅜"	36½"	350	168	27¾"	2"	2"	1"	¾"
	45	1350	521	198	99	130	42⅜"	36½"	350	195	27¾"	2"	2"	1"	¾"
3651	45	1350	576	252	108	144	51⅜"	45½"	400	186	27¾"	2"	2"	1"	¾"
	50	1500	617	250	104	154	51⅜"	45½"	400	208	27¾"	2"	2"	1"	¾"
	55	1650	618	217	97	155	51⅜"	45½"	400	226	27¾"	2"	2"	1"	¾"

Note.—PeerFin Radiators are tapped 2 in. for both steam and return connections but can be reduced to sizes given in table. Eccentric reducers must be used. PeerFin Radiators can be connected with either right or left hand steam supply.

Skinner Bros. Mfg. Co., Inc.

Home Office: 1490 S. Vandeventer Ave., St. Louis, Mo.

Eastern Office: 1013 Flatiron Bldg., New York, N. Y.

Baltimore, Md....619 N. Edgewood St.
Birmingham, Ala...Watts Bldg.
Boston, Mass....Little Bldg.
Buffalo, N. Y....Walbridge Bldg.
Chicago, Ill....Fisher Bldg.
Cincinnati, O....Merc. Library Bldg.
Cleveland, O....Marshall Bldg.
Detroit, Mich....2816 Eaton Tower
Indianapolis, Ind. Architects & Builders Bldg.
Kansas City, Mo....Mutual Bldg.
Louisville, Ky....1197 Starks Bldg.
Philadelphia, Pa...Pennsylvania Bldg.
Pittsburgh, Pa....8 E. Lacock, NS.
San Francisco, Calif. 411 Finance Bldg.
Tulsa, Okla....221 W. First St.
Washington, D.C...3500–14th St. NW

Sales Offices in Other Principal Cities

SKINNER BROS. UNIT HEATERS

Recommended for heating, ventilating, air conditioning industrial buildings, regardless of size, whether of permanent or temporary construction, sawtooth or monitor, single or multistory. In paper and pulp mills, dye houses, packing plants, laundries, dairies and buildings in which steam vapor, condensation and drippings are troublesome, Skinner Bros. Steam Coil Heaters are installed to eliminate these conditions. Installations in thousands of buildings throughout the country demonstrate their versatility and ability to heat buildings of any type of construction.

Making all types of unit heaters, floor type or suspended, steam or direct fired, prime or extended surface coils, we are in a position to always recommend the type which best fits your building requirements.

Skinner Bros. Unit Heaters may be operated with either live or exhaust steam, and high or low pressure may be used.

Coils of each heater are tested with 150 lb. hydraulic pressure before leaving factory. Fans of the heater may be operated by electric motor, steam turbine, or gas engine. The fans in the heaters are given a static and dynamic balance in order to insure the highest efficiency and smoothness of operation.

Catalog will be furnished on request, giving detailed capacities and dimensions.

Skinner Bros. "Steam Coil" Air Heater

SKINNER BROS. STEAM COIL UNIT HEATERS

Capacities

Recirculating Air at 60 deg. Steam Pressure 5 lb.

Size	Cu. Ft. per Minute	Horsepower	B.t.u. per Hour	Final Temperature	Lbs. Condensation
448	6,000	2	471,000	132	490
560	10,000	3	851,000	138	887
672	15,000	5	1,256,000	140	1299
784	25,000	10	2,025,000	125	2109

Write for Catalog Giving Other Capacities

SKINNER BROS. TYPE "UA" UNIT HEATER

Capacities

Recirculating Air at 60 deg. Steam Pressure 5 lb.

Size	Cu. Ft. per Minute	Horsepower	Revolutions per Minute	B.t.u. per Hour	Final Temperature	Lbs. Condensation
22–1	1,750	½	1160	113,000	126	118
22–2	3,500	¾	1160	226,000	126	235
22–3	5,250	1½	1160	339,000	126	353
33–2	7,000	1½	1160	445,000	125	463
33–3	10,500	2	1160	668,000	125	696
44–2	9,000	2	870	574,000	125	597
44–3	13,500	3	870	861,000	125	896

Skinner Bros.
Type "UA" Unit Heater

SKINNER BROS. "SUSPENDED TYPE" UNIT HEATER

Skinner Bros. Patented
"Lightweight" Air Heater

Capacities

Recirculating Air at 60 deg. Steam Pressure 5 lb.

Size	Cu. Ft. per Minute	B.t.u. per Hour	Final Temperature	Lbs. Condensation
A–53	2,200	139,000	120	177
B–68	3,700	242,000	122	248
C–110	5,900	368,000	118	396

SKINNER BROS. "Patented" Direct Fired Heater

This is the outgrowth of a demand for equipment having the versatilities and efficiencies of the Unit Heater and not requiring a boiler. Buildings that are heated intermittently; isolated buildings to which it is impractical to pipe steam for heating purposes, but which require warmth in winter; and buildings under construction in cold weather are found to be excellently suited to the Direct Fired Heater.

For Fuel, coal, coke, wood, gas or oil may be used.

Capacities

Size	Cu. Ft. per Minute	Horsepower	Sq. Ft. Heating Surface	B.t.u. per Hour
A	2,900	1	48	16,000 to 300,000
B	5,400	1½	65	300,000 to 600,000
C	8,400	3	88	600,000 to 1,000,000

Skinner Bros.
Patented
"Direct Fired" Air Heater

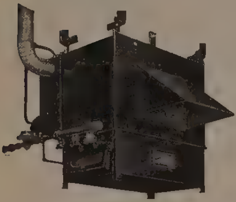
Texo Heater & Mfg. Corp.

(Formerly TEXO SALES CO., INC.)

220-230 Madison Avenue
Covington, Ky.

"SUNNYAIRE" & "Sterling" Gas-fired Unit Heaters
SUNNYAIRE Heat Cabinets

All With Forced Air Circulation. 100 per cent Automatic Control

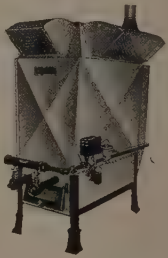


Specifications
"SUNNYAIRE" AND "STERLING" GAS-FIRED CEILING TYPE UNIT HEATERS

Size No. of Heater	Sq. In. Warm Air Pipe Capacity	B.t.u. Input	Overall Size of Casing (Inches) W. × H. × D.	Fan Motor Input, H. P.	Approximate Weight, Lb.
1	400	90,000	47 x 42 x 34	1/10	500
3	600	125,000	47 x 45 x 34	1/8	550
5	800	170,000	47 x 53 x 36	1/6	625
7	1,100	250,000	48 x 61 x 36	1/4	700
9	1,500	350,000	48 x 76 x 36	1/2	800
11	2,000	500,000	48 x 82 x 38	3/4	900

Specifications
"SUNNYAIRE" GAS-FIRED FLOOR TYPE UNIT HEATERS

Size No. of Unit Heater	Sq. In. Warm Air Pipe Capacity	B.t.u. Input	Overall Size of Casing (Inches) W. × H. × D.	Fan Motor Input, H. P.	Approximate Weight, Lbs.
1	400	90,000	28 x 57 x 60	1/10	500
3	600	125,000	28 x 67 x 66	1/8	550
5	800	170,000	30 x 80 x 70	1/6	625
7	1,100	250,000	34 x 86 x 74	1/4	700
9	1,500	350,000	38 x 96 x 85	1/3	800
11	2,000	500,000	42 x 100 x 90	1/2	900



Specifications
"SUNNYAIRE" HEAT CABINETS, with Forced Air Circulation

Size No.	B.t.u. Input	Suitable for Space (Cu. Ft.)	Equiv. Rad., Sq. Ft.	Overall Size of Casing (Inches) W. × H. × D.	Fan Motor Input, H. P.	Approximate Weight, Lb.
21	31,000	4,000	130	27 x 28 x 12	1/20	275
25	52,000	7,000	200	32 x 28 x 12	1/20	300
29	68,000	10,000	275	36 x 28 x 12	1/16	325
33	75,000	14,000	300	40 x 28 x 14	1/10	350
170-1	68,000	10,000	275	29 x 53 x 12	1/10	300
170-2	100,000	16,000	400	29 x 56 x 19	1/10	400
170-3	150,000	20,000	550	29 x 60 x 28	1/8	500

Below.—Typical "Sunnyaire"—"Sterling" Gas-fired Unit Heater Installation. 2,100,000 B.t.u. Heat Loss, Heated at Cost of $.0023 per Cubic Foot of Space per Season

Thermal Units Company

Subsidiary of Mechanical Manufacturing Company

Pershing Road and Loomis Street Chicago, Ill.

30 Church Street
NEW YORK, N. Y.

THERMAL UNIT
INTEGRAL SECTION
HEATERS
PATENT PENDING

239 Causeway Street
BOSTON, MASS.

The Thermal Unit System of Space Heating

The line includes unit heaters, blast coils and concealed radiators for a wide range of uses.

Integral Heating Section

The outstanding feature of the Thermal Unit is the one-piece aluminum-alloy casting which includes the steam channel and extended heating surfaces from inlet to outlet as an integral unit. There are no joints, welds, flanges or soldered connections to open up as the metal expands or contracts. This construction withstands water-hammer and other destructive forces. Even freezing in service cannot damage it. All Thermal Unit castings are tested to 450 lb. hydrostatic pressure before shipment.

Stream-line Core

Airplane-wing design of the steam core cuts down resistance to the passage of air through the channels between the fins, while the smooth surfaces, rounded edges and parallel spacing add yards to the distance that the heated air is projected. The large size of the core and the high velocity of the air induce rapid steam condensation and rapid release of heat units. Conductivity of heat is rapid with minimum penetration or conduction losses.

The louvers are designed on the airplane principle, assuring unusual efficiency in directing the air currents. They are hinged separately to secure various angles of deflection.

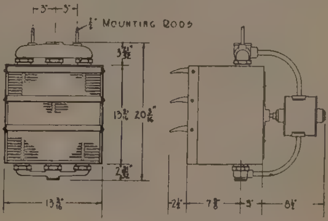
Motor is standard type, enclosed and generously rated, quiet and durable. Fan is four-blade aluminum construction, riveted to axle hub and built for long service.

The assembly is enclosed in a trim, sheet metal cabinet as illustrated. It may be suspended from steam line or installed on wall or ceiling. Brief operating data and dimensions are given below.

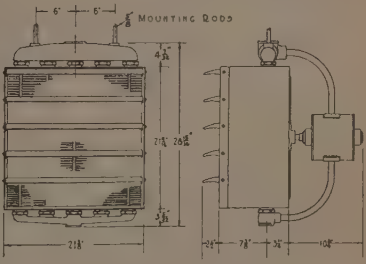
Thermal Unit Systems of Space Heating

Description	Model 12	Model 20	Model 30
Air velocity.....ft. min.	1,000	1,200	1,200
Air velocity, cu. ft. min.	1,000	3,000	6,500
Motor..............hp.	1/10	1/6	1/2
Net weight..........lb.	95	165	360
Shipping weight......lb.	116	202	444

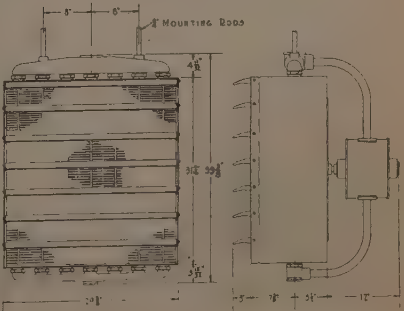
A very comprehensive engineering data book will be sent upon request.



Model 12—Thermal Unit

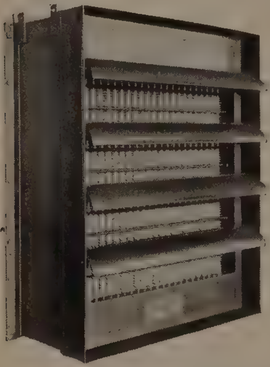


Model 20—Thermal Unit



Model 30—Thermal Unit

THERMIDAIRE
CORPORATION
2441-45 CHARLOTTE STREET
KANSAS CITY, MO.



"**Thermidaire Unit Heaters** are **Quiet, Dependable** and **Efficient,** and when equipped with **Three Speed Motors** are **Unusually Quiet.**

"Heating elements are all copper with **welded or fused joints,** capable of standing 150 lbs. steam working pressure.

"Made in either **Floor** or **Ceiling Types** using **Propellor** or **Multi-Blade Fans.** Full information can be obtained from any agent or from the main office.

"**Recirculating Ducts, Direct Fired Units, and Ventilating Fans.**

"Table below applies to the type unit illustrated."

Ratings Based on 5 lbs. Steam Pressure at the Heater

Size	C.F.M.	H.P.	Rm. T	Disc. T	B.t.u.	E.D.R.	Height	Width	Depth	Supply	Return	Shipping Wt.
5	500 at 1140 r.p.m.	1/20	50 60 70	130 137 145	45,000 43,500 42,000	180 174 168	23⅛	15⅛	18	1¼	1	114
8	800 at 850 r.p.m.	1/10	50 60 70	135 141 145	76,800 72,000 67,200	304 288 269	26⅛	17⅞	18	2	1	137
10	1000 at 1140 r.p.m.	1/10	50 60 70	131 136 141	90,000 84,000 78,000	360 336 312						
15	1500 at 850 r.p.m.	1/8	50 60 70	135 140 145	143,600 134,800 125,900	575 540 504	30⅛	24⅛	18	2	1	176
20	2000 at 1140 r.p.m.	1/6	50 60 70	131 136 140	180,000 168,000 156,000	720 672 624						
25	2500 at 850 r.p.m.	1/8	50 60 70	131 136 140	225,000 210,000 195,000	900 840 780	33⅛	26⅝	18	2½	1¼	215
30	3000 at 1140 r.p.m.	1/3	50 60 70	125 130 136	252,000 224,000 216,000	1000 896 854						
40	4000 at 850 r.p.m.	1/4	50 60 70	131 136 141	360,000 336,000 312,000	1440 1344 1250	42⅜	34⅛	30½	2½	1¼	340
50	5000 at 850 r.p.m.	1/3	50 60 70	131 136 141	450,000 420,000 390,000	1800 1680 1560	47⅜	39⅛	32½	3	2	400
60	6000 at 690 r.p.m.	1/2	50 60 70	131 136 141	540,000 504,000 468,000	2160 2020 1870	51⅛	43¾	32½	3	2	425

The Trane Company

La Crosse, Wis.

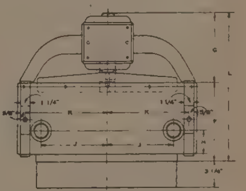
See Pumps, page 766; Heat Cabinets pages 654-655; Heating Specialties, pages 838-839

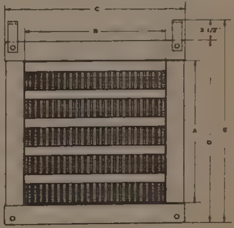
BRANCHES IN ALL PRINCIPAL CITIES

TRANE UNIT HEATER

Front View of Unit Heater

Trane Unit Heaters are of the extended surface, blow through type. The heating element is constructed of copper steam tubes to which non-ferrous metal fins are attached by a patented process. No soldered or welded joints are used. Steam tubes are rolled into heavy cast iron inlet and outlet headers by a special method which gives a stronger joint than found in water tube boilers.





Fans are cast aluminum, special Trane design. Motors of standard manufacture are used.

Three types of units are available—the suspended type shown in the illustration, a recirculating box type which incorporates the unit shown, and a floor type unit with centrifugal fan. Additional information on any size or model will be sent on request.

DIMENSIONS

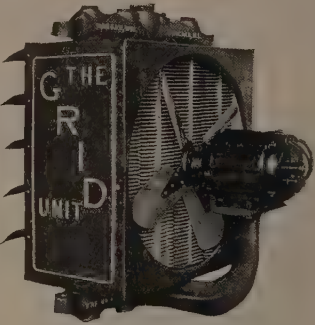
Heater Size	A	B	C	D	E	F	G	H	J	K	L	Pipe Tap
12	12"	12"	16½"	17"	19½"	10 1/16"	7½"	3 3/16"	5⅜"	7½"	17⅝"	1¼"
15	15"	15"	20"	20"	22½"	10 1/16"	8 25/32"	3 1/16"	7"	9 3/16"	18 27/32"	1½"
18	18"	18"	23"	23"	25½"	10 1/16"	8 25/32"	3"	8½"	10 11/16"	18 27/32"	1½"
24	24"	24"	29½"	29"	31½"	10 1/16"	8 25/32"	3"	11¾"	13 15/16"	18 27/32"	2"
24-A	24"	24"	29½"	29"	31½"	10 1/16"	13 5/16"	3"	11¾"	13 15/16"	23⅜"	2"

Unit Heater and Cooler Co.

Wausau, Wisconsin

FIRST NATIONAL BANK BLDG.
CHICAGO, ILL.

SALMON TOWER BLDG.
11 WEST 42ND ST., N. Y.



THE GRID UNIT
(A product of the D. J. Murray Mfg. Co.)

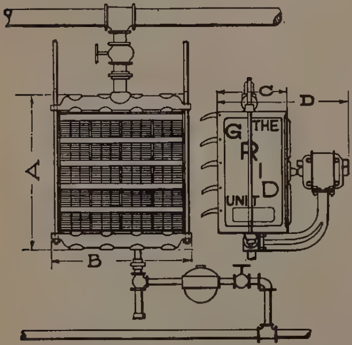
Grid Units are attractive, compact, light weight, strong, safe and efficient. Heating element affords unrestricted flow of air and permits a large volume at a moderate temperature.

The Grid Unit is constructed for constant use with minimum attention. Able to handle a large volume of air and give it a relatively small temperature rise. Extremely high temperature in air leaving the heater is avoided. Circulates large volume of air and distributes it evenly to all parts of the building.

Performance and construction guaranteed.

Grid Units may be suspended from a pipe line, or from rods to truss or rafters. Both methods may be used at the same time.

Heating Elements are composite castings of close grained gray iron and aluminum alloy. Steam chamber is gray iron capable of withstanding highest pressures ordinarily used on heating systems, while the alloy fins are of light weight and cast integral with the iron center.



Typical Installation of Grid Unit Heater

Few joints, none brazed, welded or soldered.

The Manifolds are gray iron castings with lugs for attaching supporting rods, thus taking all strains off connections between manifolds and heating elements.

The Casing or Cabinet is made of pressed sheet steel, securely attached to manifold. Will not rattle.

Cooling and Refrigerating. Grid Units are adapted for the circulation of cold water, sodium or calcium brine, by direct connections to refrigerant pipe lines. Direct Expansion ammonia may be used with safety.

GRID DATA

Model No.	Dimensions				Face Area Sq. Ft.	Motor		Volume C.f.m.	Velocity C.f.m.	Capacities 5 lb. Pres. 60 deg.		Max. Trap Capacity per Hour	Net Weights	Shipping Weights	Pipe Sizes	
	A	B	C	D		Hp.	R.p.m.			B.t.u.	Sq. Ft. Rad.				Sup.	Outlet
15	22	18	11¼	20	1.56	1/10 1/20	1750 1150	1700 1200	1100 770	76080 53280	317 222	115	200	250	1¼	¾
20	27	23¼	11½	21½	2.78	1/6 1/10	1150 850	3000 2400	1100 880	136000 108800	566 450	200	250	350	2	1
25	32	28½	11½	28	4.34	½ ¼	1150 850	4700 3700	1100 880	217300 173950	906 725	300	500	600	2	1
30	38	33¼	13¾	29	6.25	1½ ½	1150 850	8200 6600	1300 1050	382500 306000	1600 1280	450	700	800	2½	1¼

York Heating and Ventilating Corp.

York Building, 16th and Sansom Streets Philadelphia

Branch Offices and Representatives in All Principal Cities

York Heat-Diffusing Units for Heating Factories, Shops, Garages, Etc.

YORK
HEAT-DIFFUSING
UNITS

Operating Economies—

1. High velocity heat diffusion holds heat in the working zone until its principal energy has been utilized.

2. Reduces overheating of upper areas.

3. Heats large floor areas quickly.

4. A single Unit of correct capacity will heat uniformly a floor space up to 60 ft. by 200 ft. Comparatively few Units are required even for large plants.

5. The work of installation is reduced. Mains are shortened, and fewer branches and fittings are needed.

6. Fuel is saved through less overheating of upper areas; a shorter heating-up period; an easier control of room temperature.

7. Cost of complete installation will ordinarily range from 10 to 50 per cent below cost of direct radiation, pipe coils or central blower system.

8. York's large production makes possible a superior product at a relatively low price.

Heat-Diffusing Units, Housed Fan Type— Five sizes and capacities are standard: Nos. 322, 333, 334, 344, 353. Sizes vary from 18 to 30 in. in width, 3½ ft. to 7 ft. in length. All Units can be used on steam or hot water at pressures from 0 to 200 lb. All are tested at 1000 lbs. hydrostatic pressure. Fresh air intakes and regulating dampers can be furnished at small extra charge.

Note: These Units can be supplied for suspension where it is impossible to place them on the floor.

Kroy Unit Heaters, Disc Fan Type— Five sizes are available for the few applications where this type Unit is suitable. Capacities range from 40,000 to 240,000 B.t.u. or the equivalent of 166 to 1,000 sq. ft. of Direct Radiation.

Capacities

	Size Unit	R.p.m.	C.f.m. at Temp. in the Fans	H. P. Motor	Recirculating Air at 60°F. Entering Unit and Steam at 2 Lb. Gauge Pressure on the Heating Surface. (See footnote.)				Air at 0°F. Entering Unit and Steam at 5 Lb. Gauge Pressure on the Heating Surface.*			No. of Air Outlets
					B.t.u. per Hour	Final Temp.	Lbs. Cond. per Hr.	Equiv. Direct Rad.	B.t.u. per Hour	Final Temp.	Lbs. Cond. per Hr.	
YORK HEAT DIFFUSING UNIT	322	1750 1160	3,350 2,220	¾ ½	215,500 156,000	125.4 132.4	223 162	898 650	319,500 231,000	91.5 101.5	332 241	2
	333	1750 1160	5,050 3,340	1½ ½	335,000 241,000	127.7 134.5	347 250	1395 1003	497,000 358,000	94.7 105.0	517 373	3
	334	1750 1160	6,700 4,440	1½ ½	455,000 328,000	129.5 136.6	471 340	1895 1368	675,000 487,000	97.4 108.2	703 507	4
	344	1750 1160	8,400 5,560	2 ¾	574,500 414,000	130.0 137.1	595 428	2390 1725	852,000 615,000	98.3 109.1	886 640	4
	353	1160 870	13,000 9,750	3 1½	765,000 612,000	119.2 123.6	792 634	3185 2550	1,135,000 909,000	82.2 88.7	1181 946	3

Note: It is understood that the specified steam pressure is to be maintained on the heating surface. A suitable pipe line drop must be added in determining the pressure to be carried at the boiler. When air is to enter the unit at a temperature below freezing, the steam pressure on the heating surface should be maintained at not less than 5 lb.

*See Chapter 9 of this issue of The Guide for B.t.u constants for other steam pressures and entering temperatures.

For 25-cycle speed and other ratings ask for complete Catalog.

Alberger Heater Company

HOWARD IRON WORKS

218 Chicago St. :-: :-: :-: **BUFFALO, N. Y.**

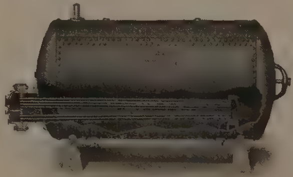
REPRESENTATIVES IN PRINCIPAL CITIES

Heaters — Condensers — Coolers — Economizers — Expansion Joints

Alberger-Buffalo Heaters are built in several types to meet a large range of standard and special water heating requirements. The standard instantaneous water tube type with floating heads is a highly efficient device embodying economy in space and maintenance cost. The storage water heater is used where the steam supply is intermittent or insufficient to take care of peak water demands. The swimming pool heater is especially designed for the purpose and is also extensively used with air washer equipment.

All of these heaters are built in either horizontal or vertical arrangement. **Alberger-Buffalo** equipment is widely used for many special requirements involving the heating or cooling of water and other liquids, and for the interchange of heat from one liquid to another.

Instantaneous Water Heater Furnished in Vertical or Horizontal Type



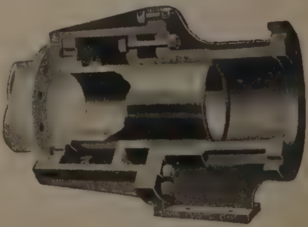
Storage Type Heater

Swimming Pool Heater Single Pass Furnished in Vertical or Horizontal Type

ARCHITECTS ENGINEERS CONTRACTORS	**If you have not already done so, send immediately for a copy of the ALBERGER HEATER DATA BOOK which gives complete information regarding capacities and dimensions of our various types, as well as service and installation data. Also remember that our experience in designing and building special heaters and coolers is available to prospective clients.**

The Howard Guided Expansion Joint is a most satisfactory means for taking care of expansion in pipe lines because it is designed with only one object in view—100% service. The construction is mechanically correct—deep stuffing box—bronze sliding sleeve—totally enclosed construction to eliminate accumulation of dirt—exterior adjustment of packing gland—ready accessibility when packing is renewed. It is a most economical joint to use because it stays on the job and leaves a satisfied customer.

Send for—Bulletin XJ-3 for full details.



Howard Expansion Joint

Bell & Gossett Company

3000 Wallace Street Chicago, Ill.

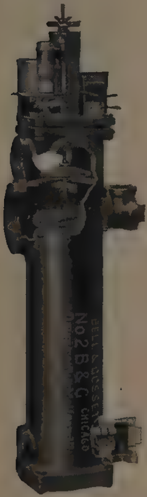
No. 30 and 45
30 and 45 Gallons
For small buildings and homes.

B. & G. Indirect Water Heaters are designed for use in smallest homes to the largest apartment buildings, country clubs, schools, etc.

In parts of the country where scale lime deposit and muddy water conditions prevail the *B. & G. removable coil feature allows for the taking out of the copper coil without disconnecting any pipes* (see cuts in folders).

Preheating fuel oil for larger installations (where industrial types of burners are used) is rapidly gaining favor. Special descriptive folder may be had on request showing exact size of heater to use on any specific job. Temperature degree rise 100° in three hours.

No. 160
160 Gallons
Double coil. A good size for apartments, garages and factory buildings.



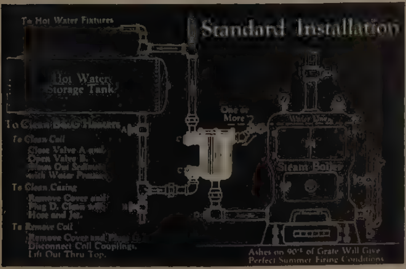
New B. & G. Double Duty Heater For Hot Water Heating Boilers

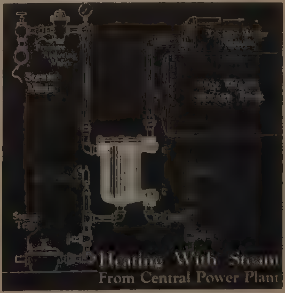
This Indirect Heater is designed for H. W. Htg. systems (oil or gas fired) up to 2,000 ft. capacity.

It will supply uniform heat plus automatic year around domestic H. W. supply.

The boiler main is piped direct to D. D. heater and the valve as shown in cut opens when room thermostat calls for heat. The boiler temperature is maintained by an azuastat with a 20 to 30 deg. range. Storage tank temperature will average around 140 deg. when azuastat is set at 150 to 180.

Send for complete details on this entirely new heating appliance.


To Hot Water Fixtures
Standard Installation
Hot Water Storage Tank
To Clean B&G Heaters
To Clean Coil
Close Valve A and Open Valve B.
To Clean Casing
Remove Cover and Plug D. Clean with Hose and Jet.
To Remove Coil
Remove Cover and Plug C. Disconnect Coil Couplings. Lift Out Thru Top.
One or More
Water Line
Steam Boiler
Ashes on 90% of Grate Will Give Perfect Summer Firing Conditions



Davis Engineering Corp.

90 West Street, New York, N. Y.

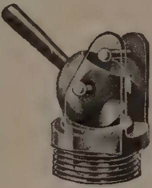
Cable Address: "Paracoil, New York" **Factory: Elizabeth, N.J.**

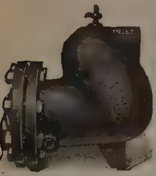
Manufacturers of Paracoil Steam Traps, Steam Specialties, Water Storage Heaters and other Heat Exchangers

PARACOIL PRODUCTS—Steam Traps, Feed Water Heaters, Feed Water Filters and Grease Extractors, Storage Water Heaters, Oil Heaters, Evaporators, Exhaust Gas-Steam Generators, Oil Coolers, Distillers.

Paracoil Steam Trap

Only one moving part, the solid recessed sphere which rotates over the valve seat. Designed for all pressures. 30 lb. steam pressure, 125 lb. and 200 lb., are carried in stock.


Paracoil Valve


Paracoil Steam Trap

Capacities up to 75,000 lb. per hour.

Guaranteed free from repairs for two years, providing installation and operating instructions are followed.

Write for Catalogue A-12.

Paracoil Steam Trap

Trap In.	Capacity Sq. Ft. Radiation	Height In.	Length In.	Width In.	List Price	Wght Lb.
½	800	8½	8	8	$15.00	24
¾	1800	8⅜	10⅛	4⅞	20.00	28
¾ special	....	11½	11½	5½	25.00	36
1–1¼	4800	12¾	12	6⅛	35.00	50
1½–2	8000	16⅜	16	10¼	68.00	112
2½	12,000	18	19	11½	100.00	185
3	23,000	20	20¾	11½	125.00	212

Larger size traps on application.

Paracoil Storage Water Heater

For heating and storing hot water for laundries, factories, hospitals, etc. The utilization of exhaust steam in this water heater effects a big fuel saving. Has steel plate shell for water and copper heating coils for steam. Pressures, 100 lb. standard and up. Sizes, 200 to 20,000 gallons per hour, heated to 180 deg. fahr. Fully described in Bulletin 74.

Paracoil Storage Water Heater

Paracoil Instantaneous Water Heater, U Tube Tank Heater, Preheater and Condensation Cooler

Connected below water level of boiler, heats water supply when fire is banked. Unexcelled for indirect heating of private garages and conservatories.

Paracoil Instantaneous Water Heater

No.	Diameter In.	Length In.	Water Inlet and Outlet In.	Steam Inlet In.	Drain In.	Capacity Gal./Hr. 40–180° F. Steam Atmos.	W'ght Lb.
200	14½	34	2	2	1	200	250
300	14½	34	2	2	1	300	250
400	14½	47	2	3	1½	400	290
500	14½	47	2	3	1½	500	300
600	16½	50	3	4	1½	600	480
750	16½	50	3	4	1½	750	500
1000	16½	62	3	4	1½	1000	560
1250	16½	62	3	4	1½	1250	580
1500	19½	70	3	5	2	1500	962
1750	19½	75	3½	5	2	1750	1010
2000	19½	80	3½	6	2	2000	1083
2500	21½	81	3½	6	2	2500	1252
3000	21½	87	4	7	2½	3000	1301
4000	21½	99	4	8	2½	4000	1400
5000	21½	110	4	10	2½	5000	1481
7500	26	95	5	12	3	7500	1915
10000	26	108	5	14	3	10,000	2125
12500	26	120	5	14	3	12,500	2241

Nos. 200 to 1250 cast iron shell, and Nos. 1500 to 12,500 steel shell.

Paracoil U Tube Type Tank Heater

Size No.	Capacity, Gals.		Hot Water Radiation Sq. Ft.	Diam. In.	Length In.	W'ght Lb.
	Below Water Level	With Live Steam				
1	350	650	260	7½	27½	90
2	700	1300	520	11¾	40¾	220
3	1050	1900	780	14½	47	375
4	1350	2500	1000	16½	50	500

Larger sizes on application. Capacity rating, 100 deg. temperature rise in 3 hours (40 to 140 deg.). Capacity rating with live steam based on ½ lb. steam pressure.

Indirect Residence Water Heater

Paracoil Fire Pot Type Water Heater

Indirect Heaters, connected below water line of steam or vapor boilers. Fire Pot type (for use in connection with Paracoil Indirect) for hot air furnaces or hot water boilers. Write for bulletins.

O. E. Frank Heater and Engineering Co., Inc.

Offices in All Principal Cities

OEF BUFFALO Olive E. Frank

BUFFALO, N. Y.

O. E. F. Products.—U-Tube and Straight Tube Storage Heaters, U-Tube and Straight Tube Instantaneous Heaters, U-Tube and Straight Tube Feed-water Heaters, U-Tube and Straight Tube Swimming Pool Heaters, Bleeder Turbine Heaters, Domestic Service Heaters, Power Plant Heaters, Oil Coolers, Special Heat Exchange Equipment for Industrial Plants.

O. E. F. Storage Heaters are furnished in either the U-Tube or Straight Tube types to meet your requirements.

Tanks are made of high quality flange boiler steel. Tube Sheets of rolled steel, Castings of heavy gray iron, and Tubes of heavy gauge copper.

O. E. F. U-Tube Storage Heater

All Heaters, unless otherwise specified are constructed for a working pressure of 100 lb. Information for higher pressures furnished on request.

When it is necessary to use both high and low pressure steam, the steam chamber and tubes can be so arranged as to eliminate installation of a separate tube bundle.

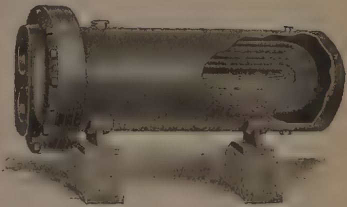
All tube bundles or heating elements are removable from the tank for ease in inspection, cleaning, or repairing.

O. E. F. Storage Heaters

For heating water from 50 to 180 deg. fahr. with steam at 212 deg. fahr.

Storage Capacity Gal.	141	370	940	1445	2956	2538	2961
Tank Size Inches	24 x 72	36 x 84	48 x 120	54 x 144	60 x 168	72 x 144	72 x 168
Gallons per Hour							
100	C-5	K-5	W-5	CX-5	MX-5	PX-5	RX-5
200	C-11	K-11	W-11	CX-11	MX-11	PX-11	RX-11
500	C-27	K-27	W-27	CX-27	MX-27	PX-27	RX-27
800	C-43	K-43	W-43	CX-43	MX-43	PX-43	RX-43
1000	....	K-54	W-54	CX-54	MX-54	PX-54	RX-54
1500	....	K-81	W-81	CX-81	MX-81	PX-81	RX-81
2000	....	K-108	W-108	CX-108	MX-108	PX-108	RX-108
3000	....	......	W-162	CX-162	MX-162	PX-162	RX-162
5000	....	......	W-269	CX-269	MX-269	PX-269	RX-269

O. E. F. U-Tube Instantaneous Heaters and Economizers—An economical heater low in price but having high heating efficiency and made of best materials. Extensively used for heating water instantaneously or for connection to storage tanks. Also for use as economizers in cooling condensate in steam systems or generators in hot water heating systems.



O. E. F. Instantaneous U-Tube Heater and Economizer

These heaters are adaptable for connecting below the water line of the boiler.

Capacities and General Dimensions O. E. F. U-Tube Instantaneous Heaters

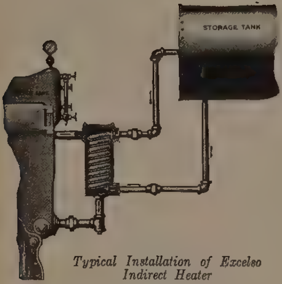
Heating Water from 50–180 deg. fahr., with Steam at 212 deg. fahr.

Gallons per Hour	Size	Width In.	Length Ft.-In.	Steam In.	Water In.	Drain In.
100	U-6	11	4-9⅞	3	1½	1
500	U-15	13½	6-3¼	3	2	1½
800	U-24	13½	6-3¼	3	2½	1½
1000	U-30	16	6-3¼	3	2½	1½
1500	U-45	16	7-4¾	4	3	1½
2000	U-60	19	7-5¾	4	3	1½
3000	U-90	19	7-5¾	6	4	2
5000	U-150	22¼	7-7¾	8	4	3

Excelso Products Corporation

65 Clyde Avenue, **Buffalo, N. Y.**

Excelso Direct Water Heaters



Typical Installation of Excelso Indirect Heater

The Excelso Indirect Water Heater is easily connected below the water line of any steam or vapor heating boiler in any old or new installation.

Cannot interfere with combustion or the firing of boiler.

Cannot over heat the water.

Consists of a heavy copper coil heating element fitted in a cast iron shell by means of patented ground joint connection. All parts are interchangeable and easily accessible.

Represent a most inexpensive and modern method of heating water.

Double Coil Excelso Heater

Excelso Double Coil Heaters

Excelso Double Coil Heaters are especially designed for large residences, small apartments and stores where requirements for hot water are rather large.

Triple Coil Excelso Heater

Excelso Triple Coil Heaters

Excelso Triple Coil Heaters are designed for heavy duty work to furnish hot water for large apartments, industrial plants, small hotels, etcetera. The heaters are easily installed in batteries so that almost any hot water requirement can be met. The heaters may be very easily serviced because of their superior construction.

Dual Coil Excelso Heater

Excelso Dual Coil Heaters

Excelso Dual Coil Heaters—these large Dual Coil heaters with capacities from 1,200 to 2,000 gallons below the water line are built to meet the demands of large apartments, hotels, office buildings, hospitals, etc. The same ground joint coil installation is used as in the smaller size of heaters and the construction is of the best. The wide range of sizes give an easy choice of the right heater for any particular job. Of course, they may be used in batteries to take care of great quantities of properly heated water.

Capacities—Dimensions—Prices

	SINGLE COIL							DOUBLE COIL				TRIPLE COIL			DUAL COIL		
Size of Heater	Jr.	11	12	13	14	15	16	25	26	27	28	35	36	37	42	44	46
Length . . . in.	8½	10½	14	11½	15	19½	24½	12½	15	19	23¼	21	25	29	21½	25¼	29¼
Width . . . in.	. . .	. . . .	. .	. . . .	. .	. . . .	. . .	. . . .	. .	. .	. . . .	. . .	. . .	. . .	26	26	26
Diameter . . . in.	5	5	5	6½	6½	6½	6½	9	9	9	9	13¾	13¾	13¾	13¾	13¾	13¾
Shell openings . . . in.	1	1	1	1½	1½	1½	1½	2	2	2	2	3	3	3	4	4	4
Coil openings . . . in.	¾	¾	¾	1	1	1	1	1½	1½	1½	1½	2½	2½	2½	3	3	3
Weight, crated . . . lbs.	12	14	19	30	38	43	50	65	70	90	100	200	225	240	360	410	470
List Price . . .	$12.50	$30	$40	$50	$60	$70	$80	$120	$150	$180	$210	$310	$400	$490	$610	$780	$950

Heating Water Below Water Line of Steam or Vapor Boilers

	SINGLE COIL							DOUBLE COIL				TRIPLE COIL			DUAL COIL		
Size of Heaters . . .	Jr.	11	12	13	14	15	16	25	26	27	28	35	36	37	42	44	46
Tank Capacity gals.	30	30	42	60	82	120	140	160	180	250	372	600	800	1000	1200	1600	2000
	. .	32	52	66	90	. . .	. . .	. . .	220	300	420	. . .	. . .	. . . .	. . . .	. . . .	. . . .
	. .	40	. .	. .	100	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . . .	. . . .	. . . .	. . . .

Temperature rise 100 degrees in 3 hours.

Heating Water With Live Steam

	SINGLE COIL							DOUBLE COIL				TRIPLE COIL			DUAL COIL		
Size of Heaters . . in.	Jr.	11	12	13	14	15	16	25	26	27	28	35	36	37	42	44	46
Tank Capacity . gals.	45	50	75	100	150	200	220	250	300	450	600	900	1200	1500	1800	2400	3000

Temperature rise 100 degrees in 3 hours at 5-lb. pressure.

Many tanks are installed too small and heaters should always be ordered to correspond with work required rather than size of tank. Also make liberal addition in capacity when circulating system is used.

Excelso Heaters with special sulphur resisting metal coils are furnished to preheat fuel oil for oil burners—greatly improves operation of burner and permits use of heavier and cheaper grades of oil.

Radiation in remote part of the buildings can also be handled with **Excelso** Heaters. There is a size to accommodate one radiator or the complete radiation of a building.

Used extensively for hot water heating in connection with central steam.

We will be pleased to furnish more complete information upon request.

The Patterson-Kelley Co.

99 Park Avenue - New York City

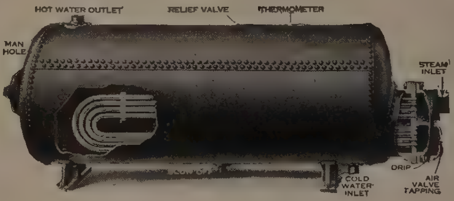
Hot Water Heaters for all purposes. Pool Heaters and Converters. Preheaters, Heat Exchangers, Heaters for Chemicals, Gases, Oils. Coolers for Brine, Chemicals, Gases, Oil and Water.

The Patterson Combined Hot Water Service and Storage Heater, Type B, is for any service where requirements for **hot** water are not constant, or where a large volume must be stored for sudden heavy demands.

We guarantee to furnish heaters that will deliver the quantity of hot water called for. Without obligation our Engineering Department will be glad to give engineers the benefit of our 49 years' experience.

General Specifications

Constructed like a high grade boiler—of heavy steel plate. Steam inlet and outlet chamber is a heavy, grey iron casting. Tube head is a heavy, steel forging into which both ends of each tube are expanded. Tubes are of pure, cold drawn seamless copper and "∩" shaped to provide against contraction and expansion strains. Heater is for any service and in any required size per tables below. Write us for engineering advice.



HEATING CAPACITIES—

40° F. to 180° F.—Steam at Atmospheric Pressure

No.	Gallons per Hour	Approx. Wt. in Lb.	No.	Gallons per Hour	Approx. Wt. in Lb.
1H	100	200	15H	2000	700
2H	150	215	16H	2500	800
3H	200	235	17H	3000	900
4H	250	255	18H	3500	1050
5H	300	285	19H	4000	1200
6H	400	315	20H	4500	1350
7H	500	350	21H	5000	1500
8H	600	370	22H	6000	1750
9H	700	400	23H	7500	2000
10H	800	425	24H	10000	3200
11H	1000	450	25H	12500	3800
12H	1250	500	26H	15000	4500
13H	1500	550	27H	20000	5100
14H	1750	600	28H	25000	5800

Note.—To specify Type B. Heaters, combine the numbers of the required storage and heating capacities. For example, "One Patterson Type B. Heater with No. 22 S. and No. 17 H." has 1000 gallons storage with 3000 gallons hourly heating capacity.

STORAGE CAPACITIES

No.	Dimensions in Inches	Capacity in Gals.	Approx. Wt. in Lbs.	No.	Dimensions in Inches	Capacity in Gals.	Approx. Wt. in Lbs.
1 S	24 x 48	94	650	21 S	42 x 144	860	2450
2 S	24 x 60	118	750	22 S	42 x 168	1000	2800
3 S	24 x 72	141	850	23 S	42 x 192	1155	3100
4 S	24 x 84	164	950	24 S	48 x 96	750	2600
5 S	30 x 60	180	875	25 S	48 x 120	940	2925
6 S	30 x 72	215	1000	26 S	48 x 144	1125	3350
7 S	30 x 84	255	1150	27 S	48 x 168	1300	3840
8 S	30 x 96	285	1300	28 S	48 x 192	1500	4200
9 S	30 x 120	360	1500	29 S	54 x 120	1190	3500
10 S	36 x 72	310	1250	30 S	54 x 144	1425	3900
11 S	36 x 84	365	1400	31 S	54 x 168	1665	4300
12 S	36 x 96	415	1550	32 S	54 x 192	1900	4700
13 S	36 x 108	475	1700	33 S	60 x 120	1400	4300
14 S	36 x 120	500	1850	34 S	60 x 144	1700	4950
15 S	36 x 144	640	2100	35 S	60 x 168	2000	5600
16 S	42 x 72	430	1500	36 S	60 x 192	2240	6200
17 S	42 x 84	500	1650	37 S	72 x 174	3000	7000
18 S	42 x 96	575	1800	38 S	84 x 168	4000	8700
19 S	42 x 108	650	1950	39 S	96 x 168	5200	10000
20 S	42 x 120	720	2200	40 S	96 x 192	6000	11000

The Whitlock Coil Pipe Company

Manufacturers and Engineers

HARTFORD, CONN.

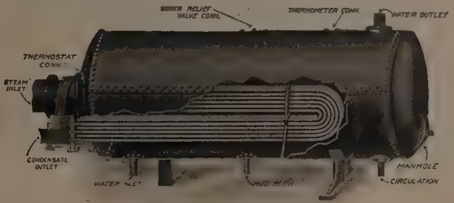
Baltimore, Md.
Boston, Mass.
Buffalo, N. Y.
Charlotte, N. C.
Chicago, Ill.
Cincinnati, O.
Cleveland, O.
Dallas, Tex.
Denver, Colo.
Detroit, Mich.
Houston, Tex.
Indianapolis, Ind.
Kansas City, Mo.
Memphis, Tenn.

WHITLOCK SERVICE WATER HEATERS

New Orleans, La.
New York, N. Y.
Omaha, Neb.
Philadelphia, Pa.
Pittsburgh, Pa.
Portland, Ore.
Rochester, N. Y.
San Antonio, Tex.
San Francisco, Calif.
Seattle, Wash.
St. Louis, Mo.
St. Paul, Minn.
Tacoma, Wash.

Darling Bros. Montreal, Manufacturers of Whitlock Heaters in Canada

See Telephone Directory for Local Address



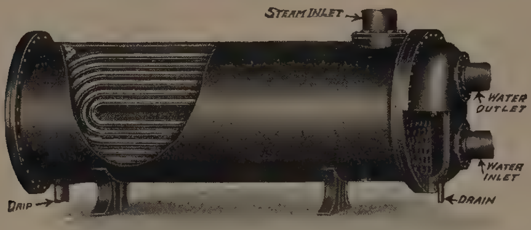
Whitlock type "K" storage heaters are manufactured in both horizontal and vertical types. The table shows sizes of the horizontal heaters only. We will gladly furnish dimensions of horizontal heaters and vertical heaters upon request. That this type of heater is of particularly sturdy construction is evidenced by the increasing number of prominent engineers and architects who are specifying their use in all types of buildings, including many of the largest and finest buildings constructed.

Whitlock Type K Storage Heaters, Horizontal

SHELLS To be used with Type K Heating Section Shell Prices include Cradle. Manhole 11"x15"							HEATING SECTIONS Capacity based on Heating from 40° to 180° with Steam at 0 lbs. pressure. For other temperatures and Steam Pressures see Bulletin No. 27				
Number	Gallons One Filling	Diameter of Shell	Length of Shell	Thickness of Shell	Thickness of Head	Weight of Shell	Number	Gallons per Hour	Maximum Size Steam Pipe Inches	Smallest Shell into which Section will Fit Inches	Weight of Entire Heating Section Lbs.
1	65	18	60	1/4	3/8	400	H 0	100	2	18x 48	75
2	80	18	72	1/4	3/8	450	H 1	150	2	18x 60	80
3	118	24	60	1/4	3/8	600	H 2	200	2	18x 72	90
4	141	24	72	1/4	3/8	700	H 3	250	3 1/2	18x 48	175
5	164	24	84	1/4	3/8	800	H 4	300	3 1/2	18x 48	185
6	185	30	60	1/4	3/8	750	H 5	350	3 1/2	18x 60	190
7	220	30	72	1/4	3/8	850	H 6	400	3 1/2	18x 60	200
8	255	30	84	1/4	3/8	950	H 7	500	3 1/2	18x 72	210
9	290	30	96	1/4	3/8	1050	H 8	550	3 1/2	18x 72	215
10	365	36	84	5/16	1/2	1300	H 9	600	3 1/2	18x 84	220
11	420	36	96	5/16	1/2	1450	H10	700	5	24x 60	300
12	475	36	108	5/16	1/2	1600	H11	800	3 1/2	18x 96	260
13	525	36	120	5/16	1/2	1800	H12	900	3 1/2	18x108	270
14	575	42	96	5/16	1/2	1850	H13	1000	3 1/2	18x120	285
15	720	42	120	5/16	1/2	2150	H14	1250	5	24x 84	370
16	860	42	144	5/16	1/2	2500	H15	1500	5	24x108	425
17	1000	42	168	5/16	1/2	2900	H16	1750	5	24x120	450
18	950	48	120	3/8	1/2	2850	H17	2000	6	30x 96	570
19	1140	48	144	3/8	1/2	3250	H18	2400	6	30x120	620
20	1310	48	168	3/8	1/2	3700	H19	2800	6	30x132	670
21	1480	48	192	3/8	1/2	4100	H20	3200	8	36x 96	860
22	1190	54	120	3/8	1/2	3250	H21	3600	8	36x108	920
23	1430	54	144	3/8	1/2	3700	H22	4000	8	36x120	950
24	1670	54	168	3/8	1/2	4200	H23	4400	8	36x132	1020
25	1900	54	192	3/8	1/2	4700	H24	4800	10	36x 96	1200
26	1420	60	120	7/16	9/16	4300	H25	5400	10	36x108	1300
27	1710	60	144	7/16	9/16	4900	H26	6000	10	36x120	1380
28	2000	60	168	7/16	9/16	5600	H27	7000	12	42x 96	1950
29	2300	60	192	7/16	9/16	6200	H28	8000	12	42x 96	2000
30	2460	72	144	7/16	9/16	5700	H29	9000	12	42x108	2300
31	2880	72	168	7/16	9/16	6400	H30	10000	12	42x108	2460

DIRECTIONS FOR USE—Select the size storage you require and combine its designating number with the number which designates the desired hourly output. Assuming a required storage of 1000 gallons (No. 17 shell 42 x 168) and a required hourly output of 1750 gallons (No. H16 Heating unit) you would specify a Whitlock Type K No. 17H16.

WHITLOCK TYPE R INSTANTANEOUS HEATERS



This type of heater is used extensively as an instantaneous heater in connection with a separate storage tank, as a swimming pool heater, as a hot water convertor for use with a heating system as well as for various special conditions.

Standard sizes of the 2 and 4 pass heaters are shown in the table. Dimensions on multi-pass heater will be furnished on request.

Standard Sizes, Capacities, Dimensions and Weights

Size No.	MULTI PASS, TEMP. RANGE 40° F. to 180° F.						4 PASS TEMP. RANGE 40° F. to 120° F.					
	Capacity Gallons per Hour	Over-all Length	Diameter of Shell	Size Water Connections	Size Steam Connections	Weight	Capacity Gallons per Hour	Over-all Length	Diameter of Shell	Size Water Connections	Size Steam Connections	Weight
0	25	15⅜	7	¾	1	90	80	11⅜	7	¾	1	80
1	60	26⅜	7	¾	1¼	125	150	16⅜	7	¾	1¼	100
2	150	37⅜	7	¾	1½	160	300	21⅜	7	1	2	115
3	200	39½	9½	1	1½	280	480	26⅜	7	1	2	135
4	250	48½	9½	1	2	325	650	31⅜	7	1¼	2½	150
5	300	31¾	9½	1	2	250	800	38⅜	7	1¼	2½	170
6	400	40¾	9½	1¼	2½	300	960	24¾	9½	1½	3	220
7	500	43¾	9½	1¼	3	325	1350	30¾	9½	2	3	270
8	600	48¾	9½	1¼	3	350	1600	35¾	9½	2	3½	300
9	800	52	12	1½	3½	575	2100	43¾	9½	2	4	350
10	1000	61	12	1½	3½	645	2600	55¾	9½	2½	5	420
11	1250	74	12	1½	4	760	3300	52	12	2½	5	620
12	1500	59⅞	15	2	5	870	4000	61	12	3	6	700
13	2000	72⅞	15	2	5	1020	5300	79	12	3	6	860
14	2500	59	17	2½	6	1035	6600	55⅞	15	3½	8	940
15	3000	71	17	2½	6	1175	8000	65⅞	15	4	8	1070
16	4000	89	17	2½	8	1420	10500	71	17	5	10	1390
17	5000	74⅞	20	3	8	1910	13300	83	17	5	10	1580
18	6000	88⅞	20	3	10	2185	16000	72⅞	20	5	10	2020
18½	7000	101⅞	20	3	10	2475	18500	82⅞	20	5	12	2230
19	8000	64⅝	26	4	10	2800	21000	92⅞	20	6	12	2430
19½	9000	71⅝	26	4	10	3000	24000	62⅝	26	6	12	2800
20	10000	78⅝	26	4	12	3220	26700	67⅝	26	6	12	3000
21	12500	94⅝	26	4	12	3725	33300	82⅝	26	6	14	3480
22	15000	89	30	5	14	4125	40000	73	30	8	14	4015
23	20000	113	30	6	16	4860	53300	92	30	8	16	4600
24	25000	96	36	6	18	6350	66700	83	36	10	20	6100
25	30000	112	36	6	20	7175	80000	95	36	10	22	6900
	Sizes 0 to 8 inclusive, have ¾" O. D. No. 18 B. W. G. Copper Tubes. Remainder have 1" O. D. No. 17 B. W. G. Copper Tubes.						Sizes 0 to 10 inclusive, have ¾" O. D. No. 18 B. W. G. Copper Tubes. Remainder have 1" O. D. No. 17 B. W. G. Copper Tubes.					

Whitlock Heat Transfer Products include the following types of apparatus in addition to the Storage and Instantaneous Heaters shown above: Feed Water Heaters; Heat Exchangers; Fuel Oil Heaters; Superheaters; Condensers and Coolers for all kinds of liquids; Also pipe coils of any kind of pipe or tubing and Air and Ammonia Receivers.

Additional information and quotations covering any of this apparatus will be gladly furnished upon request.

Carrier-Lyle Corporation

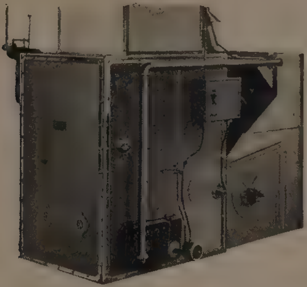
850 Frelinghuysen Avenue, **Newark, N. J.**

Affiliated with the Carrier Engineering Corporation

THE CARRIER WEATHERMAKER

A SCIENTIFIC AIR-CONDITIONING SYSTEM FOR HOMES

Compact new gas-burning unit for homes introduces a warm-air heating system that is clean; positive in circulation of air; healthful and automatic in operation.



A complete heating and air-conditioning system for homes in winter. Approved by American Gas Association *Testing Laboratory. Made to take summer cooling unit, (now under development), without change in present system.*

The Carrier Weathermaker makes indoor weather to order.

1. It controls the moisture content of the air, maintaining a fixed, healthful relative humidity.
2. It warms the air, using manufactured or natural gas as fuel.
3. It filters the air, removing dust, dirt and bacteria.
4. It circulates the air by centrifugal blower, insuring positive, uniform distribution of heat.
5. It operates automatically.

In controlling warmth, humidity and air motion, the Carrier Weathermaker represents an original and constructive improvement in house heating.

Development—The Carrier Weathermaker is an adaptation for domestic use of the well-known Carrier Systems now operating in nearly 3,000 theatres, stores, factories and other large buildings.

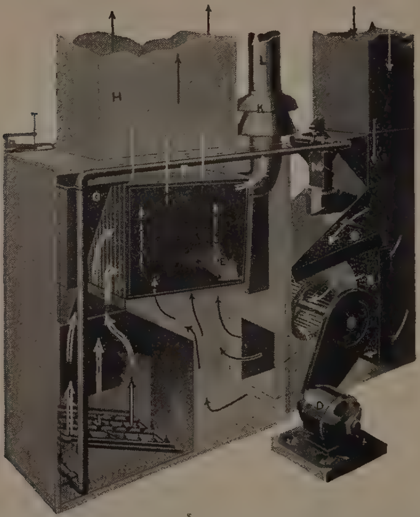
Operation—The simplicity of the Carrier Weathermaker is indicated by the diagram on following page. Air enters through return duct (*A*)—passes through filters (*B*) into blower (*C*) and is forced out under uniform pressure into heat-interchanger (*E*), where it is warmed. It rises to (*F*), where humidity is furnished by humidifier (*G*); then passes into mixing chamber (*H*) and is returned to rooms through warm-air ducts. Circulation is continuous and positive.

Combustion—The heat is supplied by gas burner (*J*). Combustion chamber and gas passages are entirely separate from the air passages.

The Carrier Weathermaker operates with an overall efficiency of 90 per cent.

Temperature Regulation—The thermostatic control mechanism (*M*) operates a throttling valve on the gas line. It regulates the gas supply to the demand for heat.

Protective Controls—A thermostatic pilot control operates to close the main gas supply should pilot go out or gas-flow fail; a heat-limiting control turns off the gas supply before overheating, through any cause, can occur.



Outline arrows show combustion gases. Other arrows show air travel.

Filters—The air is cleaned by oil-coated, metallic-fiber filters.

Humidity Control—Moisture is added to the circulating air by the humidifier (*G*). Once adjusted to provide the desired relative humidity of the house atmosphere, the humidifier functions automatically.

Positive Circulation of Air—The blower provides forced circulation of air throughout the house. It is indirectly driven by a separately-mounted electric motor.

Non-corroding Construction—The combustion chamber and interchanger are made from a special nickel-chrome steel which is leak-proof and impervious to rust and acids.

Space Economy—The forced distribution of air permits the Carrier Weathermaker to be placed anywhere in the cellar, with resulting economy of space. It permits, also, the use of smaller ducts and long runs.

RATINGS, CAPACITIES, GAS CONSUMPTION, WEIGHTS

Weathermaker Number	Output B.t.u. per Hour	Fan Capacity Cubic Feet per Minute	Motor Horsepower	Gas Consumption Cubic Feet per Hour*	Approximate Shipping Weight Pounds
1	75,000	600	1/8	155	800
2	155,000	1200	1/6	318	1100
3	225,000	1800	1/4	455	1400

*Gas consumption figures based on manufactured gas of 550 B.t.u. and 3½ in. water gauge at pressure regulator. (*A. G. A.* Standard).

DIMENSIONS

Weather-maker Number	Overall Length	Overall Width	Height	Height Including Draft Diverter	Size of Return Air Opening	Size of Air Discharge Opening	Size of Gas Supply Line	Diameter of Flue Conn.
1	6′-3⅝″	3′-3½″	3′-11⅝″	4′-10″	12″ x 14″	11″ x 22″	1″	7″
2	6′-3⅝″	4′-2⅞″	3′-11⅝″	4′-10⅝″	12″ x 25⅜″	22″ x 22″	1¼″	8″
3	6′-3⅝″	5′-2¼″	3′-11⅝″	4′-11⅛″	12″ x 36¾″	22″ x 33″	1½″	9″

Grinnell Company, Inc.

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Executive Offices: **Providence, R. I.**

Offices, Plants and Branches

Albany, N. Y.
Atlanta, Ga. (Plant and Foundry)
Auburn, R. I. (Plant and Foundry)
Baltimore, Md.
Boston, Mass.
Buffalo, N. Y.
Charlotte, N. C.
Chicago, Ill. (Branch)
Cincinnati Ohio
Cleveland, Ohio (Branch)
Columbia, Penna. (Foundry)
Dallas, Texas
Detroit, Mich
Hartford, Conn.
Indianapolis, Ind.
Kansas City, Mo.
Kearny, N. J. (Branch)
Milwaukee, Wis.
Minneapolis, Minn. (Branch)
Newark, N. J.
New Orleans, La.
New York, N. Y.
North Charlotte, N C. (Branch)
Philadelphia, Penna. (Branch)
Pittsburgh, Penna. (Branch)
Plymouth, Fla.
Providence, R. I. (Plant and Foundry)
Rochester, N. Y.
St Louis, Mo. (Branch)
Warren, Ohio (Plant and Foundry)

GRINNELL COMPANY OF THE PACIFIC

Los Angeles, Cal. (Branch)
Oakland, Cal. (Branch)
San Francisco, Cal. (Branch)
Seattle, Wash. (Branch)

GRINNELL COMPANY OF CANADA, LTD.

Montreal, Que. (Branch)
Vancouver, B. C. (Branch)
Toronto, Ont. (Plant and Foundry)
Winnipeg, Man.
Oshowa, Ont. (Foundry)

PRODUCTS AND SERVICES—

Complete Service on materials to specification on Power Plant Piping, Industrial Piping, and Industrial Heating Systems; Fabricated piping including bends, welded headers, lap joints and the Grinnell Triple XXX line of products for Super Power; Grinnell Equiflo Valve; Grinnell Pipe Hangers and Fittings; Grinnell Thermolier (A Development in Unit Heaters), ThermOflex Heating Specialties.

Also Humidifying Systems; Constant Level Size Circulating Systems; Piping for acids and other special materials; Pipe Fabricating, Bending and Threading; Welding.

Brass, Bronze and other Castings; Valves: Air Relief, Globe, Angle, Cross, Check, Quick Opening and Closing, Non-return, Tank, Pressure, Reducing and Regulating, Safety and Y.

Pipe Bends and Coils; Unions, Tees, Ells and Nipples; Cast Iron, Steel and Wrought Iron Pipe; Pipe Rolls; Steam Traps.

Automatic Sprinkler Systems.

For data on ThermOflex Heating Specialties, see page 862.

Equiflo Valve

A Revolutionary Development in Forced Hot Water Heating**—** One of the chief difficulties in the way of a broader use of forced hot water heating systems with their many important advantages has been the determination of pipe sizes by the complex and arduous method of calculating frictional resistances. Failure to do this, plus easily possible installation mistakes has resulted in many unsatisfactory installations of this type of heating system.

This whole problem has now been simplified by the invention of the *Grinnell Equiflo Valve.*

The Grinnell Equiflo Valve for forced hot water heating ***permits:***

1. The calculation of pipe sizes for this system by simple tables, similar to those commonly used in connection with the design of vacuum steam systems.

2. Change in locations of radiators or piping during installation to take care of local construction conditions without recalculation of pipe sizes.

The Grinnell Equiflo Valve for forced hot water heating ***accomplishes:***

1. More nearly perfect equalization of flow to every radiator than has ever been

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

practical by even the most careful calculation of pipe sizes. Size or location makes no difference.

2. The introduction of sufficient frictional resistance to completely overcome that trouble so pronounced in most forced hot water heating systems which is due to the well-known war between pump head (a constant) and the gravity or temperature head (a variable). This insures absolutely equalized circulation at all temperatures.

3. Lower pumping costs.

The Grinnell Equiflo Valve:

1. Serves as the regular shut-off valve for each radiator. It is of the packless type.

2. Is so designed that after the installation is completed a multiple-orifice cartridge or tube, having a definite resistance pre-determined by Grinnell Company, is dropped into place in the valve.

In order to obtain all the advantages of this new development, it is only necessary for the Consulting Engineer to specify that *each radiator shall be equipped with a Grinnell Equiflo Valve.* This device is marketed through the regular heating trade, and proper results are guaranteed by the standing of Grinnell Company in the hot water heating field.

Fabricated Piping Materials: Lap Joints, Pipe Bends Welded Headers—

The making of pipe bends, welded headers, lap joints of every description, and a complete line of miscellaneous pipe fabricated materials, has for many years been a specialty of Grinnell Company. In work of this kind experienced workmen are essential to quality products. Due to its Engineering and Laboratory facilities, its training of welders, and other pipe fabrication developments, Grinnell Company has a corps of workmen who can be depended upon to translate a specification into a satisfactorily finished product.

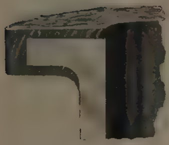
These experienced workmen have the best modern facilities to work with. Pipe fabrication plants are strategically located at Auburn, Rhode Island; Warren , Ohio; and Atlanta, Georgia. Grinnell pipe bends are true to radius and free from buckles and flat places. Bends are furnished according to dimensions from standard and extra heavy wrought iron and steel pipe, as well as from seamless steel tubing.

One item that works to standardize quality in Grinnell-made pipe bends is our mechanical filling and hammering machines which replace the old method of hand filling and eliminate the human element in this important feature of pipe bending work. In filling of pipe for bends, specially prepared sand is used which does not crystalize or adhere to the inside of the pipe.

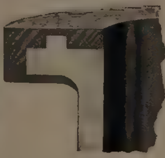
Grinnell Pipe Bends can be furnished with Lap Joint Flanges, with Screwed-on and with Welded Flanges; also with Screwed Ends or with Scarfed Ends for field welding. Lap Joints may be plain faced having 100 per cent thickness in Laps, or with Male and Female, Tongue and Groove, or "Sarlun" facings with a thickness equal to 100 per cent of pipe walls at thinnest point, and suitable for all pressures up to 1350 lb. W. S. P. at a total temperature of 750 deg. fahr.

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

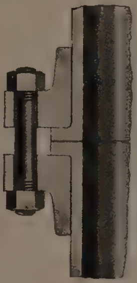


Square Lap in Rough Lap

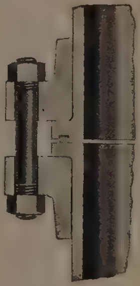


Small Tongue in Rough Lap

Above illustrations show clearly how the ample thickness of perfect metal in the rough-forged lap allows for machining front and back for any conceivable face with a finished lap of at least 100 per cent thickness and strength.



Finished Square Lap



Finished Tongue and Groove Lap

The Place of Triple XXX in Power Plant Piping

Triplex XXX is a line of fabricated piping material developed by Grinnell Company to meet the demands of high pressures and temperatures in modern power plants. It is standard with us for all working steam pressures of Series 40 (400 lb. W. S. P.) and over, and recommended for Series 30 with high temperatures. The line is complete, comprising all types of pipe joint faces, welded headers and pipe bends. Each piece of material is stamped XXX showing that it has been produced for this special service.

Grinnell Fittings—After years of buying cast iron fittings on the open market Grinnell Company concluded that the best way to obtain clean accurate fittings of uniformly high quality was to cast them in Grinnell Foundries. Grinnell Cast Iron Flat Band Fittings made to conform to the American standard approved by American Engineering Standards Committee and by the N. F. P. A. can now be obtained by other users. Impartial purchasers agree that accuracy of threading, freedom from sand holes, and smoothness of core speed up installations and reduce replacements wherever Grinnell Fittings are specified.

Grinnell Adjustable Pipe Hangers and Supports

One of the chief advantages of Grinnell Adjustable Hangers is that they permit adjustment of pipe lines after installation, thus obviating the necessity of turnbuckles or the removal of hangers. And their time and trouble-saving qualities during installation are equally exceptional. On the following pages are shown a few Grinnell Hangers and Supports of particular interest to heating engineers. Send for Grinnell Hanger Catalogue No. 5, a catalogue covering the complete line of Pipe Hangers and Supports, giving illustrations, list prices and dimensions.

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Solid Ring—Adjustable Swivel Ring—Split Ring

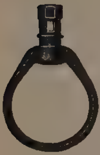


Fig. No. 101
Solid Ring

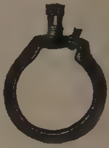


Fig. No. 104
Split Ring
Patented—No. 1,612,959

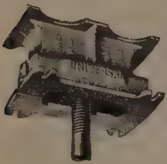
THIS Malleable Iron Adjustable Swivel Ring can be used with Coach Screw Rod or Machine Threaded Rod in connection with practically any type of Ceiling Flange, Expansion Case, Insert, etc.

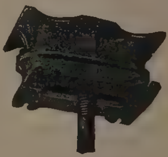
With the Swivel Shank, an adjustment of at least 1½ in. is secured by turning the nut on the shank.

An unique locking device on the Swivel Shank automatically locks, preventing loosening due to vibration in the pipe line.

The Split Ring Type has the same adjustment as in Fig. No. 101, either before or after the hinged section is bolted in place. The off-center hinging of the Ring provides sufficient seating to hold the pipe before closing the Ring. A wedge type Pin is loosely but inseparably cast into the hinged section for fastening this section after pipe is in place.

Universal Insert—Simplex Insert


Universal Insert
Fig. No. 280


Simplex Insert
Fig. No. 281

MADE of charcoal malleable iron, they have ample vertical and horizontal adjustment. Four widely separated nail slots, low height and large bottom surface all tend to minimize the chance of displacement during construction, whether nailed to wood or pasted to steel forms.

Universal inserts are made in one body size, to take a special removable nut. Nuts are furnished tapped for ⅜ in., ½ in., ⅝ in. or ¾ in. rod as required, and are automatically locked laterally by means of serrated teeth on both insert and nut.

Simplex Inserts are made in five body sizes, with nuts assembled in place and not removable, for rod tappings ⅜ in. to ⅞ in. inclusive.

Universal Clamps

(Patented—Nos. 1,134,395 and 1,568,122)

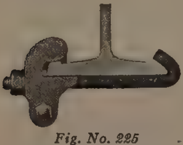


Fig. No. 225
Side I-Beam Clamp

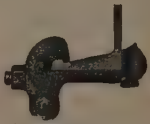


Fig. No. 226
Channel Clamp

THE Side I-Beam Clamp has ample strength for hanging ¾ to 12 in. pipe from I-Beams. Made in different sizes to fit all sizes of Standard and Bethlehem I-Beams, and most sizes of Bethlehem Girder Beams.

The Grinnell Channel Clamp, made in three sizes with varying lengths of clamp rods, will meet most of the conditions encountered in practical installation work in connection with channels.

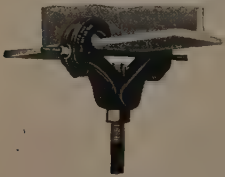


Fig. 228
U. F. S. I-Beam Clamp

UFS

(Universal Forged Steel)

I-BEAM CLAMP

(Patented—No. 1,604,590)

THE UFS (Universal Forged Steel) I-Beam Clamp is a recent addition to the Grinnell Hanger line and is an outstanding development in convenience, strength and adjustability. While made only in three sizes, it covers the whole range of beam sizes from the smallest to Bethlehem 24-in. Forged steel construction gives to each size the same strength as the maximum rod strength involved. Rods carried range from ⅜ to 1½ in., providing for all pipe sizes up to 24 in.

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

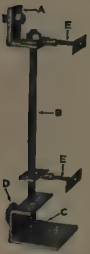


Fig. No. 192

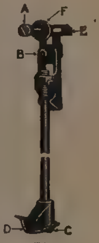


Fig. No. 190

Adjustable Wall and Wrought Radiator Brackets

THE Bracket, Fig. No. 190, is designed to support a single tier of wall radiation. A similar Bracket, No. 191, is designed to support a double tier, one in front of the other. The Wrought Bracket, Fig. No. 192, is designed to support legless radiation of the new Tube Type.

Only one bolt is necessary to securely fasten these brackets to the wall. This means low installation cost and it cuts drilling holes down to a minimum.

When hook bolt is used, it can be set without extremely accurate measurements, due to the liberal range of vertical and horizontal adjustment, and as only two or three points of the bracket touch the wall, the difficulty so often experienced with rough brickwork is practically eliminated.

Adjustable Wall Coil Hangers

(Patented—No. 1,062,372)

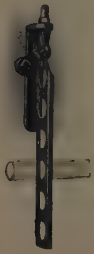


Fig. No. 160

THE Adjustable Wall Coil Hanger can be furnished with four separate brackets—two for single coils and two for double coils. The brackets locate the center of the coils 2¼ or 6¼ in. from back of bracket. Where double coils are used the second hangs 3½ in. in front of the first.

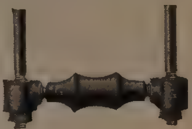


Fig. No. 171

Single Pipe Rolls

GRINNELL Single Pipe Rolls are especially designed to take care of expansion and contraction. Rolls are made hollow which means small surface in contact with roll rod. The Adjustable Sockets permit vertical adjustment at the roll. The nut at the bottom of the hanger rod fits into a recess in the socket, thus preventing loosening or turning from vibration.

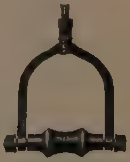


Fig. No. 174

Adjustable Swivel Pipe Roll

THE Adjustable Swivel Pipe Roll supplies the need for an adjustable type of pipe roll hanger with single hanger rod. It is unique inasmuch as vertical adjustment can be made by use of the Swivel Shank at the top of the hanger.

Adjustable Pipe Stand—Anchor Chair—Pipe Seat—

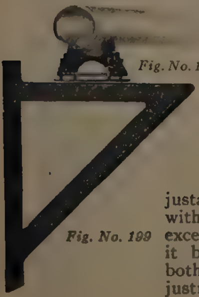


Fig. No. 196

Fig. No. 199

WELDED STEEL BRACKET, Fig. No. 199 is light in weight and was designed primarily for use with the Grinnell Adjustable Pipe Stand, Fig. No. 196, Anchor Chair, Fig. No. 197 and Pipe Seat, Fig. No. 198.

These combine the strongest type of brackets and pipe supports. The Adjustable Pipe Stand as used with the Steel Bracket has excellent adjustment features, it being possible to obtain both vertical and lateral adjustment.

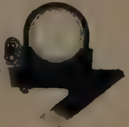


Fig. No. 197

Fig. No. 198

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Copper Housing Makes for Durability and Fine Appearance

Grinnell Thermolier

THE Grinnell Thermolier is a modern development of unit heaters. This principle of heating is rapidly becoming standard for use in many kinds of buildings. The reason for this may be briefly stated: (1) Low initial cost; (2) economy of operation; (3) adaptability; (4) maintenance; (5) depreciation.

This unit is the result of more than three years' intensive investigation and test by the Grinnell organization which for 70 years has been recognized as a leader in industrial heating work. No pains have been spared to make it a most dependable, efficient and long-lived unit. Heat is obtained from brass-finned, seamless, copper U-tubes rolled into a cast-iron header. No solder is used for joints and there are no flat horizontal surfaces to catch dirt.

One model 800 Thermolier may be used to heat a floor area of 500 to 5000 sq. ft. Units may be controlled manually or automatically, singly or in groups.

Installation and piping are extremely simple and inexpensive, hence the unit may be moved from one location to another at small cost if found desirable on account of changes in building or occupancy. Furnished in several sizes for factory offices and small rooms.

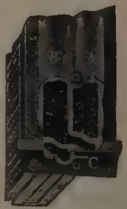
Thermoliers provide excellent distribution of heat free from objectionable drafts. May be used when desirable with steam pressures up to 125 lb.

Specifications—Fan: Grinnell, special, of rugged construction. **Motor:** Heavy duty, oversize, enclosed, moisture-proof. **Housing:** Heavy copper, insuring exceptionally long life. Rubbed copper finish protected by high temperature lacquer. **Frame:** Heavy pressed steel, providing rugged support for motor and fan. **Special features:** Adjustable swivel hanger rod couplings; louvers rigid, but easily adjustable; integral cooling leg insuring complete drainage through one ¾-in. trap on Models 300 to 800, ½-in. on Models 100 and 200, or 1-in. on Models 1200 and 1600. For pressures not exceeding 100 lb., a thermostatic trap of proper construction can be used and should be attached directly to unit.

Simple piping connections, both on same side, with close return trap

Particular attention is called to the integral cooling, a unique feature of the Thermolier which is of vast importance to the heating man. Due to the construction of the header in Thermolier, steam circulation and removal of condensation in this unit are distinctly different than is usual in such heaters.

Steam is delivered into Chamber "A" of the header and circulates from there through the pitched U tubes, carrying its condensation with it into Chamber "B." By partitioning off the tubes at the bottom of the Steam Supply Chamber "A," these lower tubes carry all condensation from Chamber "B" into Drain Chamber "C." In passage of this condensation through these tubes, the air from the fan is rapidly carrying off heat just as it does in the rest of the unit. The result is that these lower tubes form an efficient internal cooling leg, integral with the unit. The actual cooling effect of this construction is equal to a run of more than 100 feet of the ordinary, exterior cooling leg piping.



Unique header construction forces all condensation through integral cooling leg

GRINNELL COMPANY

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Tubes expanded into cast-iron header

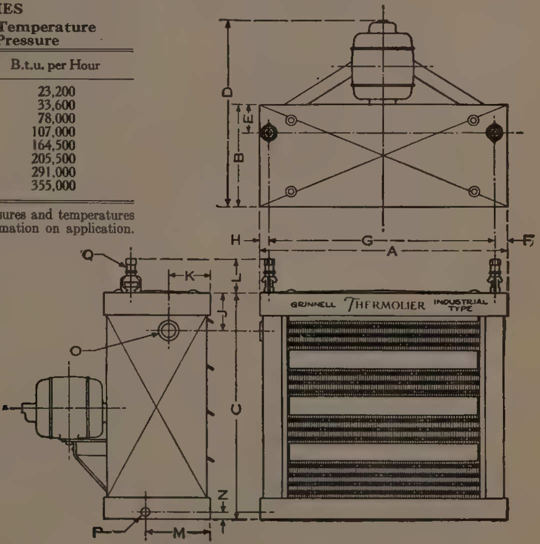
Due to the efficient functioning of the internal cooling leg, it is practical with the Grinnell Thermolier to make an exceedingly close connection of the return trap, as indicated on the drawing on previous page. The condensation coming from the unit is cool enough so that the trap will operate continuously even when the unit is working at maximum capacity for long periods. This feature, combined with the fact that the steam supply connection is at the same end of the unit, makes for compactness and neatness in the piping connections.

CAPACITIES

60°F. Entering Air Temperature
5 Lb. Steam Pressure

Model Nos.	B.t.u. per Hour
100	23,200
200	33,600
300	78,000
400	107,000
600	164,500
800	205,500
1200	291,000
1600	355,000

Data Book covering other pressures and temperatures and complete installation information on application.



DIMENSIONS

Model Numbers	A	B	C	D	E	F	G	H	J	K	L	M	N	O Supply	P Return	Q	No. of Louvers
100—200	14 1/4	8 1/2	11 3/4	*15	2 3/16	15/16	12 5/8	11/16	2 3/4	3 1/4	2 5/8	5 11/16	13/16	1 1/4	1/2	†3/8	3
300—400	21 1/8	10 7/16	18 7/16	*17	3 3/8	1	19 1/8	1	3 3/4	4 1/16	3 1/8	6 5/8	13/16	1 1/2	3/4	†1/2	3
600—800	27 3/4	11 7/8	25 1/2	*21	3 1/4	1 9/16	25	1 3/16	7 5/8	4 3/4	4	6 3/4	1 1/16	2	‡1	†5/8	4
1200—1600	36 1/2	12 3/4	32 5/8	*25	4 1/4	1 1/2	33 3/4	1 1/4	9 7/16	5 3/16	5 7/16	6 7/8	1 1/4	2 1/2	‡1 1/4	†7/8	6

All Dimensions given in Inches.
*This Dimension varies slightly with different motors.
†Adjustable Swivel Coupling (furnished with Thermolier) Tapped Standard Bolt Thread.
‡Outlets bushed to pipe size next smaller than indicated in table.

AEROFIN CORPORATION

850 Frelinghuysen Avenue
Newark, N.J.

Manufacturers of AEROFIN
Standardized, Light-Weight, Fan System Heat-Surface

11 West 42nd Street
NEW YORK

Burnham Building
CHICAGO

Paul Brown Building
ST. LOUIS

Land Title Building
PHILADELPHIA

Oliver Building
PITTSBURGH

United Artists Building
DETROIT

AEROFIN is the modern Standardized Light-Weight Fan System Heat-Surface originated by *Fan Engineers* to meet the present-day requirements of this highly specialized field, and to afford an adaptability which permits and fosters the new and advanced applications of tomorrow.

Low Pressure, Universal and High Pressure Aerofin:

AEROFIN is built in three distinct types: Low Pressure AEROFIN, tube-plate construction, for pressures up to 50 lb. gauge; Universal AEROFIN, continuous multicoil seamless tubes, for pressures from 2½ to 150 lb. gage, and High Pressure AEROFIN, continuous seamless tubes, for pressures from 25 to 350 lb. gauge (temp. 500°F.).

Design and Construction: The heat-transfer surface in AEROFIN is a plurality of seamless copper tubes about which is wound a helix of copper ribbon, crimped on its inner edge to permit winding and to afford maximum contact between tube and fin. The extended fin surface is applied and tinned while held in position, by highly developed automatic machines, being accurately crimped and spaced. The tinning of the tube and the extended surface makes them metallicly integral, affording maximum heat transmission and permanent effectiveness. The thickness and width (height) of the extended surface, the crimping and the pitch of the helix were determined by careful experiment, to afford maximum heat transfer, uniform air flow and minimum resistance thereto. The copper tubes and fins of AEROFIN transmit heat eight times as effectively as iron. So scientifically is AEROFIN designed that air is heated more in passage through a single row of its tubes, a travel of 1⅛ in., than in passage through an entire section of cast iron surface, a travel of 9 in.

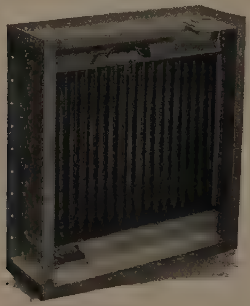


Fig. 1

In Low Pressure AEROFIN the tubes are set into flexible tube-plates by means of a highly developed joint which is tight and permanent. (See Figure 1.) In Universal AEROFIN and High Pressure AEROFIN the seamless tubes, with their extended fin surface, are continuous. (See Figs. 2 and 3.)

Low Pressure AEROFIN, Universal AEROFIN and High Pressure AEROFIN are furnished as completely encased units, ready for pipe and duct connections. The casings are built of pressed steel and are exceptionally strong and rigid, protecting the unit from all the strains of pipe connections and expansion or contraction in service. The casings are flanged on both faces, top and bottom, and template punched for bolting together adjacent units, or for duct connection.

Standard Casings: The casings of all AEROFIN Units, whether comprising one, two or three rows of tubes, are 29 in. wide, (except 6-tube Universal AEROFIN which is $21\frac{5}{16}$ in.) across tubes, from outer edge one flange to outer edge opposite flange, and 10 in. deep in direction of air flow. Length of casing is nominal tube length plus 8½ in.

AEROFIN Sizes: Low Pressure AEROFIN: Made in fifteen standard tube lengths, either one, two or three staggered rows of tubes per unit. There are thus forty-five standard units available, a range which adequately meets all requirements.

Tubes are furnished of any length between 2 ft. and 6 ft., in increments of 6 in., and between 6 ft. and 12 ft. in increments of 1 ft.

Complete tables of sizes and capacities are shown in *Bulletin G30*, mailed gratis upon request. This bulletin also contains 23 proved piping diagrams in four colors.

UNIVERSAL AEROFIN: Available in one-row or two-row units, 6-tubes or 9-tubes across face, in seventeen standard tube lengths (distance between end baffle plates, or between 180° bends) between 2 and 10 ft., inclusive, in increments of 6 in. Batteries of double width are easily assembled by setting units end-to-end, leaving space for pipe connections.

Complete information is contained in our *Bulletin G 30*, mailed gratis upon request.

HIGH PRESSURE AEROFIN: Made in five standard tube lengths (*i.e.*, length of straight section of tube, between 180° bends) 2 ft.; 2 ft. 6 in.; 3 ft.; 3 ft. 6 in.; 4 ft., either one, two or three staggered rows of tubes per unit. There are thus fifteen standard units now available, meeting practically all requirements. Since the supply and drip connections of High Pressure AEROFIN are located on the same end (Figure 3) units may be placed end-to-end, thus affording battery widths of twice the standard tube-lengths. Complete tables of sizes and capacities are shown in our *Bulletin G30*, mailed gratis upon request.

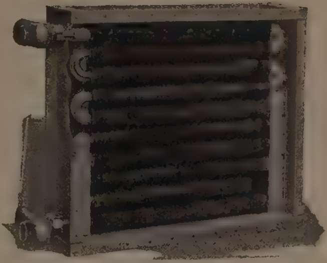


Fig. 3

Steel Supporting Legs: Standard steel supporting legs, 18 in. high, template punched to same bolt hole centers as standard casing, are furnished when ordered. These legs may be attached quickly and obviate necessity of any other foundation.

Advantages: AEROFIN weighs but 9 to 16 per cent as much as equivalent cast iron and occupies but 35 per cent of the space required by equivalent cast iron (3-row units). Two men can easily carry any AEROFIN Unit. Expensive foundations are unecessary, building re-enforcement is not required and the units may readily be suspended from beams or roof trusses, or installed snugly in any out-of-the-way corner. The light weight and remarkable compactness of AEROFIN permit design heretofore impossible, bringing a new era in Fan Engineering, enabling the Engineer or Architect to exercise his highest skill, undeterred by the weight and bulk which have limited him in the past.

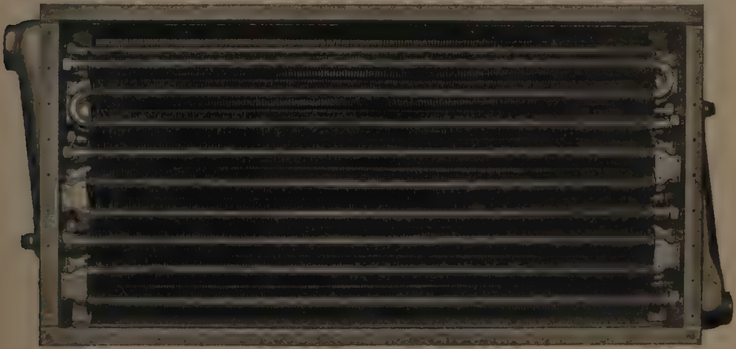


Fig. 2

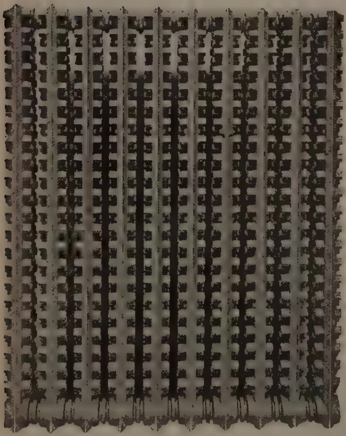
Sales: AEROFIN is sold only by manufacturers of nationally advertised Fan System Apparatus.

AMERICAN RADIATOR COMPANY

General Sales and Eastern Executive Office
40 West 40th Street, **New York**
Western Executive Office
816 South Michigan Avenue, Chicago, Illinois

Manufacturers of Ideal Boilers, American Radiators, and other Heating, Ventilating, and Refrigerating Products

VENTO
Cast Iron Heaters



Vento has a unique construction which breaks up the air currents and assures rapid steam circulation, both of which features insure full heating efficiency of all the surfaces of the heater.

Being made up into stacks which are easily handled, and having fewer joints per hundred square feet of heating surface than pipe-coils, there is less possibility of leaks. Use of Vento reduces labor installation costs, and calls for minimum space. Vento is made of cast iron, which does not rust by action of air, gases, water or summer dampness, and is exceedingly durable. Vento Heaters do not freeze, split or corrode, nor is there any effect from electrolysis.

The standard spacings of regular Vento in a stack are 5 in. centers. The distance between centers can be increased or decreased by use of hexagon nipples as herewith described.

30*, 40, 50 and 60 Inch Sections		72 Inch Sections	
Centers Inches	Sizes of Nipples Inches	Centers Inches	Sizes of Nipples Inches
5⅜	2½ x 3⅜	5⅜	3 x 3⅜
5	2½ x 3	5	3 x 3
4⅝	2½ x 2⅝	4⅝	3 x 2⅝
4**	2½ x 2		

*30 inch Nipples are all 2 inch diameter.
**Internal Nipple.

For assembling of these sections we recommend a Vento nipple wrench which is made of extra heavy drop forged steel, especially for use on right and left-hand threaded nipples having a hexagon nut at the center.

Vento does not call for any new or special conditions in either housing or steam supply and drip connections. Both live and exhaust steam may be used at the same time.

IN BLAST AND PLENUM CHAMBER WORK THE NET INSTALLED COST OF VENTO IS LESS THAN THAT OF LIGHTER FORMS OF HEATERS.

Twenty-five years of successful operation of Vento Heaters in thousands of installations in private and public buildings throughout America, Europe and Australia, disclose no failure of any kind. A copy of Engineer's Data on Vento Heating will gladly be sent on request.

ARCOBLAST HEATERS

The Encased Section

FEATURES of the ENCASED SECTION

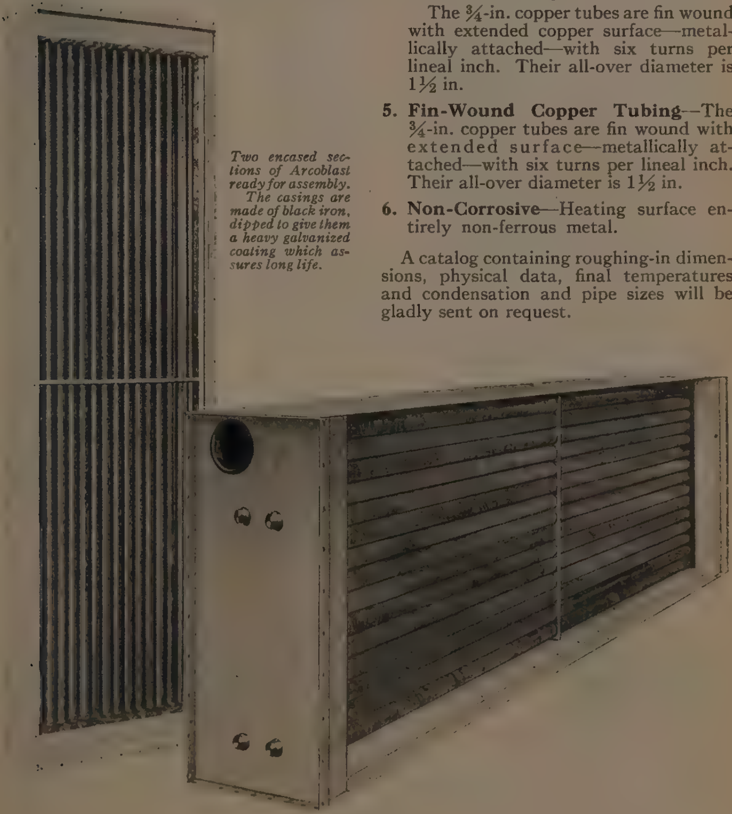
For Pressure from 5 to 200 lb.

The following outstanding features of Arcoblast will appeal to the Heating Engineer who is figuring heating surface for central fan and plenum chamber work.

1. **Galvanized Encasement**—complete and ready for pipe connections.
2. **One Piece Cast Iron Header**—The headers are cast in one piece with the tube plates three-fourths of an inch thick, thus allowing the tubes to be ex-expanded properly and held securely.
3. **No Soldered Steam-Backed Joints,** Tubes expanded in headers—Ample strength for high pressure is assured.
4. **Assured Strength with Minimum Weight**—The Arcoblast Heater is composed of staggered rows of copper tubes expanded into cast iron headers—on the opposite side of which are registering tapped openings through which the tubes are expanded. After the expanding operation the holes are closed with counter-sunk plugs.

   The ¾-in. copper tubes are fin wound with extended copper surface—metallically attached—with six turns per lineal inch. Their all-over diameter is 1½ in.
5. **Fin-Wound Copper Tubing**—The ¾-in. copper tubes are fin wound with extended surface—metallically attached—with six turns per lineal inch. Their all-over diameter is 1½ in.
6. **Non-Corrosive**—Heating surface entirely non-ferrous metal.

A catalog containing roughing-in dimensions, physical data, final temperatures and condensation and pipe sizes will be gladly sent on request.



Two encased sections of Arcoblast ready for assembly. The casings are made of black iron, dipped to give them a heavy galvanized coating which assures long life.

ARCOBLAST HEATERS

For High and Low Pressure Unit Heaters

5 to 150 Pounds

The Arcoblast Heaters, both Ideal and UH Type, have been designed to meet the rapidly expanding requirements of the **Unit Heater** manufacturer.

The construction has met with approval from our many users.

Both types are made with three-quarter inch copper tubes having extended surface metallically attached with six turns per lineal inch.

Ideal Type Arcoblast Heater

The over-all diameter is 1½ in.

The Design is rugged having no soldered steam-backed joints, non-corrosive and with ample tube steam carrying capacity together with minimum weight without impairing strength.

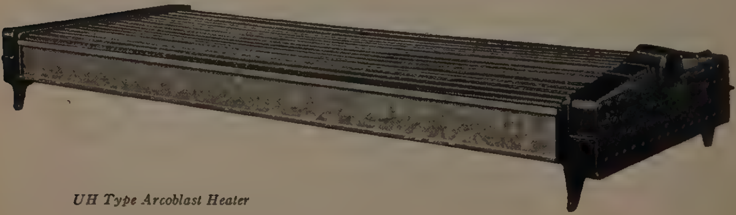
The Ideal Type as shown in the illustration is made of a two piece header construction secured together by bolts with gasket having staggered rows of copper tubes expanded into two cast iron header plates forming the supply and return headers.

The UH Type is made of a one piece cast iron header construction having staggered rows of copper tubes expanded the same way as the Ideal cast iron headers—on the opposite side of which are registering tapped openings through which the tubes are expanded. After the expanding operation, the holes are closed with counter-sunk plugs.

Between the headers on the sides of this heater galvanized filler plates are used.

The materials of construction, copper for tubes and fins and cast iron for headers offer a product which is non-corrosive.

A catalogue containing complete technical data on Ideal and UH type Arcoblast heaters will be sent gladly on request.



UH Type Arcoblast Heater

McCord Radiator & Mfg. Co.

2587 E. Grand Boulevard **Detroit, Mich.**

Manufacturers of Spiral Fin-Tubing for Unit Heaters and Concealed Radiators, for Electric Refrigeration, Automotive Radiators and Metallic Asbestos Gaskets.

McCORD tubing, now developed for use in heating and refrigeration systems, is the result of twenty-two years' experience in the building of automotive cooling systems.

The construction of McCORD tubing insures a perfect contact between the fin and the tube, insuring greatest heat transfer. McCORD solder was developed for the particular purpose of withstanding the high temperatures of heating requirements. The special "Spiral Fin-Tubing" is made by a patented process, and may be had in corrugated or plain fin.

It is made of seamless tubing, brass or copper, finished bright on inside. The corrugated or flat spiral fin is continuous with a perfect metal-to-metal contact between the fin and the tube which makes for efficient radiation. The tubing is made in either hard or soft temper and can be coiled on short radius so as to occupy the minimum of space.

For heating purposes McCORD Spiral Fin-Tubing is well adapted to unit heaters or concealed wall radiators, and is used by a number of manufacturers.

McCORD Spiral Fin-Tubing Compared on Basis of One Lineal Foot with Plain Tubing of the Same Outside Tube Diameter.

McCord Corrugated Spiral Fin-Tubing

Tube Size	Radiating Surface per Lineal Ft.	Heating Ratio
5/16"	McCord Spiral Fin-Tubing	= 70 sq. in.
5/16"	Plain Tubing	= 11¾ sq. in.
3/8"	McCord Spiral Fin-Tubing	=113 sq. in.
3/8"	Plain Tubing	= 14 sq. in.
7/16"	McCord Spiral Fin-Tubing	=122.5 sq. in.
7/16"	Plain Tubing	= 16.5 sq. in.
1/2"	McCord Spiral Fin-Tubing	=132 sq. in.
1/2"	Plain Tubing	= 19 sq. in.
5/8"	McCord Spiral Fin-Tubing	=150¾ sq. in.
5/8"	Plain Tubing	= 23¼ sq. in.
3/4"	McCord Spiral Tubing	=229 sq. in.
3/4"	Plain Tubing	= 28¼ sq. in.
1"	McCord Spiral Tubing	=375 sq. in.
1"	Plain Tubing	= 37¾ sq. in.

Sizes and Specifications

Tube Size	Width of Fin	Diameter McCord Spiral Fin-Tubing
1"	1/2"	2"
3/4"	3/8"	1 7/16"
5/8"	1/4"	1 1/8"
1/2"	1/4"	1"
7/16"	1/4"	15/16"
3/8"	1/4"	7/8"
5/16"	3/16"	11/16"

Standard lengths of tube up to 50 feet in copper or brass.

Standard gauge tube 0.028 wall. Special gauges on request.

Standard gauge fin 0.006 except ¾ in. and ⅜ in. sizes. Flat Spiral Fin 0.012.

McCord Plain Spira Flat Fin-Tubing

The Rome-Turney Radiator Co.

Rome, N. Y.

Exclusive Manufacturers of

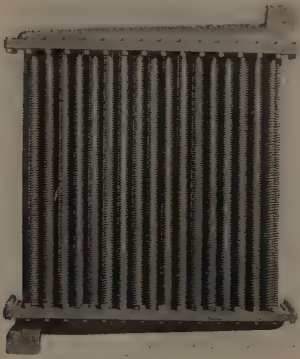
Rome HELICALFIN Tubing for Unit Heaters; Oil Coolers; Refrigeration Condensers and Heat Exchangers

Complete Unit and Blast Heaters; Lynch Concealed Copper Radiation, Bath Room Heaters; Truck and Tractor Radiators

---

The radiating surface provided by **Rome HELICALFIN** Tubes is **all** highly efficient. There are no corrugations to pocket the air and collect the dust and dirt.

Rome patented processes produce continuous **Flat** radiating fin, free of corrugations, with a tight copper to copper contact with the tube wall, insuring highest efficiency.



Rome Helicalfin Heater for Unit Heating Work

Standard HELICALFIN Heaters are sturdy and non-corrosive. The Seamless copper tubes are fused into copper bearing steel tube sheets, complying with the most exacting engineering requirements.

Rome HELICALFIN Tube Data
Standard Sizes

O. D. of Plain Tube	Width of Fins	O. D. of Finned Tube	No. Fins per Inch	Surface per Linear Foot
5/16"	3/16"	11/16"	6	54.38 Sq. In.
5/16"	3/16"	11/16"	7	61.48 " "
5/16"	3/16"	11/16"	8	68.58 " "
3/8"	1/4"	7/8"	6	85.13 " "
3/8"	1/4"	7/8"	7	96.83 " "
3/8"	1/4"	7/8"	8	108.63 " "
1/2"	1/4"	1"	5	89.80 " "
1/2"	1/4"	1"	6	103.85 " "
1/2"	1/4"	1"	7	117.95 " "
5/8"	1/4"	1 1/8"	5	106.17 " "
5/8"	1/4"	1 1/8"	6	122.77 " "
3/4"	3/8"	1 1/2"	5	187.47 " "
3/4"	3/8"	1 1/2"	6	219.27 " "
1"	3/8"	1 3/4"	5	232.70 " "
1"	1/2"	2"	5	320.70 " "
1 1/4"	1/2"	2 1/4"	5	377.20 " "
1 1/4"	5/8"	2 1/2"	5	489.20 " "
1 5/16"	5/8"	2 3/16"	5	506.50 " "
1 5/16"	7/8"	3 1/16"	5	774.50 " "

Data covering special sizes on request.

Standard construction—seamless copper tube with copper fins. Steel and brass is supplied when specified for either tube or fins. Tubes bent and formed over short radii to specifications.

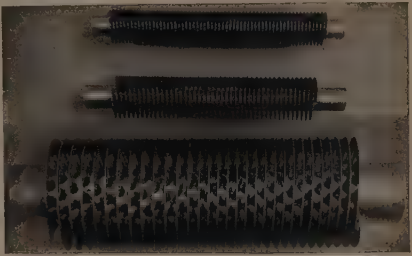
Over 25 years of experience behind Rome Products

Schutte & Koerting Co.

1154 Thompson Street **Philadelphia, Pa.**

SCHUTTE KOERTING

RADIAFIN TUBES



for air-heating and air-cooling units

S&K Radiafin Tubes have from 7 to 16 times as much surface as plain tubes of the same size and length. This feature insures maximum heating or cooling capacity with minimum quantity of tubing and low initial and operating costs.

RADIAFIN TUBING AND PIPING DATA

Type of Tube or Pipe	Size of Tube or Pipe	Width of Fins	O. D. of Finned Tube or Pipe	Pitch of Fins	Ratio of Air Contact Surface to Water or Steam Contact Surface	Total Surface per Lineal Foot	Weight per Lineal Foot	Price per Lineal Foot	Price Flanges per Pair
Seamless Drawn Brass and Copper Tubing with Copper Fins. Pressures up to 250 lbs.	1/2"	1/4"	1"	1/7"	9.93 to 1	1.05 sq. ft.	0.357 lbs.	Prices on Application	
	5/8"	1/4"	1 1/8"	1/7"	8.70 to 1	1.2 "	0.6 "		
	3/4"	5/16"	1 3/8"	1/6"	9.34 to 1	1.55 "	0.83 "		
	1"	7/16"	1 7/8"	1/5"	10.6 to 1	2.41 "	1.09 "		
	1 1/2"	5/8"	2 3/4"	1/4"	11.6 to 1	3.99 "	2.04 "		
Seamless Drawn Steel Tubing with Steel Fins. Pressures up to 250 lbs.	3/4"	1/2"	1 3/4"	3/16"	16.3 to 1	2.64 "	1.2 "		
	1"	5/8"	2 1/4"	1/4"	14.75 to 1	3.22 "	1.93 "		
	1 1/4"	3/4"	2 3/4"	5/16"	13.72 to 1	3.80 "	2.80 "		
	1 1/2"	7/8"	3 1/4"	3/8"	13.0 to 1	4.35 "	4.4 "		
	2"	1 1/8"	4 1/4"	1/2"	12.0 to 1	5.52 "	6.1 "		
	3"	1 1/4"	5 1/2"	5/8"	9.17 to 1	6.55 "	10.5 "		
Seamless Drawn Brass and Copper Oval Tubing with Copper Fins. Pressures up to 250 lbs.	7/16"x1"	1/4"	15/16"x1 1/2"	1/7"	7.6 to 1	1.33 "	0.75 "		
Standard Steel Pipe with Steel Fins. Pressures up to 125 lbs.	3/8"	5/16"	1.3"	1/6"	11.6 to 1	1.5 "	1.03 "		
	1/2"	3/8"	1.59"	1/5"	10.9 to 1	1.78 "	1.41 "		
	3/4"	1/2"	2.05"	1/4"	11.1 to 1	2.41 "	1.95 "		
	1"	5/8"	2.56"	1/4"	13.5 to 1	3.7 "	2.9 "		
	1 1/4"	3/4"	3.16"	5/16"	12.2 to 1	4.4 "	4.02 "		
	1 1/2"	7/8"	3.65"	3/8"	12.1 to 1	5.1 "	5.75 "		
	2"	1 1/8"	4.62"	1/2"	11.2 to 1	6.07 "	8.2 "		
	2 1/2"	1 1/8"	5.12"	9/16"	9.47 to 1	6.12 "	9.54 "		
	3"	1 1/4"	6.0"	5/8"	8.97 to 1	7.2 "	13.77 "		
	4"	1 1/2"	7.5"	3/4"	8.6 to 1	9.05 "	20.89 "		
	6"	1 3/4"	10.12"	1"	6.7 to 1	10.64 "	31.07 "		

The S&K Radiafin Tubes and Pipes listed above can be furnished with plain or flanged ends and in any lengths up to 15 ft. Sold with or without headers.

Winchester Repeating Arms Company

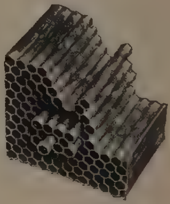
RADIATOR DIVISION

New Haven, Conn.

Manufacturers of Winchester Copper Radiators for Unit Heaters and Air Conditioning Equipment

---

CONSTRUCTION FEATURES



Large surface area in small space.
Unrestricted air and water passages.
Light weight and compactness.
Simplicity of construction and durability.

The Winchester Copper Radiator is recognized in the Heating and Ventilating industry as an exceptionally efficient and light-weight element, having features that are outstanding in radiator surface construction.

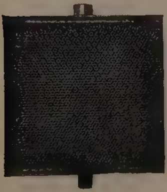
The free area is 62 per cent of the frontal area. This free area permits the passage of large volumes of air with only moderate fan power. This results in large air delivery with rapid temperature rise, power economy, and good distribution for long distances from the unit, permitting the unit to be placed at greater heights than heretofore considered possible in heating practice.

All the heating surface is direct prime surface with steam on one side and air on the other. Each seamless copper tube provides an unrestricted passage for air and yet is small enough for the passing air to have intimate contact with its surface. The indentations set up a turbulence of the air in passing through, increasing the scouring effect.

This results in a high rate of heat transfer throughout the entire heating surface and keeps the air friction loss at a minimum. There are no fins, ribs or other members used, thereby establishing a design which gives the steam a uniform close contact with the air over the entire heating surface. The tube wall construction adds greatly to this high efficiency, and the construction of the cores make them extremely light in weight without sacrificing mechanical strength.

All heating surface is made of a special grade of pure copper, which in addition to its effectiveness as a heat conductor, is strongly resistant to all normal corrosive influences.

Simplicity of contruction is another advantage. The individual copper tubes are joined by a special high temperature bonding alloy. This alloy has been especially developed by the Winchester Research Laboratory to adequately meet the strength requirements for service at the temperatures and pressures involved in steam heating work. The tubes being joined at the ends permit unobstructed and maximum space for passage of steam around them. Foreign substances present no difficulties from clogging nor will they impair the efficiency of the surface and impede the flow of water or steam. The tubes are guaranteed not to burst if radiator should freeze. In case of freezing, ice would form on the outside of the tubes, having a tendency to crush rather than to split the tubes, in which event the radiator would still function.



Winchester Copper Radiators can be furnished in any standard overall size from 12 x 12 in. up to 40 x 40 in. and in standard depths of 3, 3⅞ and 5 in.

The data tables shown (below) indicate the high rate of heat transfer possible from Winchester Copper Radiators and the extremely low friction loss.

Further details will be gladly sent you upon request.

To Specify

Winchester Copper Radiators can be supplied by unit heater manufacturers as the radiating surface of any unit heater of stock pattern or special construction if the clause "with genuine Winchester Copper Radiator" is made a part of the specification or order.

WINCHESTER COPPER RADIATORS

Final Temperatures and Condensation Rates Steam at 5 lb. gage.
Referred to Dry Air at 70 deg. and Barometer of 29.92 in. Mercury

AIR BLOWN THROUGH

Face Velocity, Feet per Minute....	400		600		800		1,000		1,200	
Temperature Inlet Air	*T*	*C*	*T*	*C*	*T*	*C*	*T*	*C*	*T*	*C*
3 in. Deep										
0°	99.8	44.7	92.0	62.1	84.8	76.2	80.0	90.0	76.1	102.8
20°	111.0	41.0	103.9	56.7	97.3	69.4	93.0	82.2	89.4	93.8
40°	122.2	36.9	115.8	51.3	109.8	62.9	105.9	74.3	102.7	84.6
60°	133.4	33.1	127.6	45.6	122.4	56.1	118.9	66.2	116.0	75.7
80°	144.6	29.0	139.5	40.1	134.9	49.4	131.8	58.3	129.3	66.4
Friction loss, Inches of Water.....	0.08"		0.12"		0.22"		0.34"		0.48"	
3⅞ in. Deep										
0°	114.3	51.4	106.0	71.5	98.5	88.5	91.8	103.1	87.1	117.4
20°	124.2	46.5	116.6	65.3	109.8	80.6	103.7	94.1	99.5	107.0
40°	134.2	42.4	127.3	59.0	121.1	72.9	115.6	85.1	111.8	96.6
60°	144.1	37.9	138.0	52.4	132.5	65.3	127.5	75.6	124.1	86.1
80°	165.0	33.3	148.6	46.2	143.8	57.3	139.4	66.7	136.4	76.1
Friction loss, Inches of Water.....	0.10"		0.18"		0.33"		0.48"		0.66"	
5 in. Deep										
0°	129.8	58.3	123.2	83.2	115.5	104.1	110.5	124.6	103.8	140.2
20°	138.4	53.0	132.3	75.7	125.3	94.8	120.8	113.5	114.7	127.7
40°	147.0	48.1	141.5	68.5	135.2	85.9	131.0	102.8	125.5	115.3
60°	155.5	42.7	150.6	61.4	145.0	76.5	141.3	91.7	136.4	103.2
80°	164.1	37.8	159.8	53.8	154.8	67.6	151.6	80.5	147.2	90.8
Friction loss, Inches of Water.....	0.12"		0.24"		0.41"		0.60"		0.84"	

T = Temperature of Air Leaving Heater. C = Pounds of condensation per sq. ft. net frontal area per hour.

WINCHESTER COPPER RADIATORS

Final Temperatures and Condensation Rates Steam at 5 lb. gage.
Referred to Dry Air at 70 deg. and Barometer of 29.92 in. Mercury

AIR DRAWN THROUGH

Face Velocity, Feet per Minute....	400		600		800		1,000		1,200	
Temperature Inlet Air	*T*	*C*	*T*	*C*	*T*	*C*	*T*	*C*	*T*	*C*
3 in. Deep										
0°	85.2	38.2	80.4	54.2	75.4	67.8	71.8	80.8	68.1	91.9
20°	97.7	35.1	93.3	49.4	88.7	61.8	85.5	73.8	82.1	83.8
40°	110.2	31.6	106.2	44.7	102.1	55.9	99.1	66.7	96.1	75.7
60°	122.7	28.2	119.1	39.9	115.4	49.9	112.8	59.4	110.1	67.5
80°	135.2	25.0	132.0	35.0	128.8	43.9	126.5	52.3	124.1	59.4
Friction loss, Inches of Water.....	0.06"		0.10"		0.18"		0.28"		0.40"	
3⅞ in. Deep										
0°	99.7	44.8	93.5	63.2	89.9	80.9	85.6	96.2	81.4	109.7
20°	110.9	41.0	105.2	57.7	102.0	73.6	98.1	87.5	94.2	100.0
40°	122.1	36.8	117.0	52.1	114.0	66.7	110.5	79.2	107.0	90.3
60°	133.4	33.0	128.8	46.5	126.1	59.4	123.0	70.8	119.9	80.6
80°	144.6	28.8	140.5	41.0	138.2	52.4	135.5	62.2	132.7	70.8
Friction loss, Inches of Water.....	0.08"		0.15"		0.27"		0.40"		0.55"	
5 in. Deep										
0°	120.0	53.8	113.1	76.1	109.0	97.9	104.0	117.0	99.1	133.5
20°	129.4	49.0	123.1	69.4	119.4	89.0	114.8	106.8	110.4	121.9
40°	138.8	44.5	133.2	62.7	129.8	80.5	125.6	96.1	121.7	109.9
60°	148.2	39.6	143.2	56.1	140.1	72.1	136.5	85.9	133.0	97.9
80°	157.6	34.7	133.2	49.4	150.5	63.2	147.3	75.7	144.2	86.3
Friction loss, Inches of Water.....	0.10"		0.20"		0.34"		0.50"		0.70"	

T = Temperature of Air Leaving Heater. C = Pounds of condensation per sq. ft. net frontal area per hour.

WOLVERINE TUBE CO.

SEAMLESS COPPER BRASS & ALUMINUM

1453 Central Avenue, **Detroit, Michigan**

Sales Offices—Cleveland; Chicago; Atlanta; Los Angeles; Denver; Dayton, Ohio; New York City; Dallas, Texas

Seamless Copper, Brass and Aluminum Tubing For:

Unit Heaters; Water Heaters; Oil Burners; Air Compressors; Refrigeration Compressors; Lubrication Systems; Thermostatic Devices; Gas, Oil and Air Lines; Water Coolers; Pressure Gages; Humidifiers; Cooling Systems.

Seamless Copper Tubing—From $\frac{1}{16}$ to $1\frac{1}{2}$ in.

Seamless Brass Tubing—O. D. any gauge.

Seamless Aluminum Tubing—From $\frac{1}{16}$ to $1\frac{1}{2}$ in. O. D., any gauge.

Coils and Bends of Seamless Copper, Brass and Aluminum.

All shapes and sizes which use tube from $\frac{1}{16}$ to $1\frac{1}{2}$ in. outside diameter, any gauge. Unbrazed lengths up to 100 ft.

Seamless Copper Tubing

Wolverine seamless copper tubing is made from cast deoxidized billets. All operations are controlled so that the finished tubing meets the most rigid specifications for bending, flaring and freedom from flaws.

This tubing is annealed bright by the most scientific electrical methods and under electrical control. There is no possibility of scale—an important feature.

Seamless Brass Tubing

All of our brass tubing is a 70-30 mixture. This gives excellent results in threading and the higher copper content makes brass of this character more desirable than 2 and 1 or 60-40 brass for bending, flaring and reducing.

Particular care is taken to produce finished tubing which is bright and clean.

Seamless Aluminum Tubing

Wolverine Seamless Aluminum Tubing is bright, clean and accurately drawn to close dimensions. It can be bent and flared to exact specifications. It provides an excellent means to reduce the weight of tubing bends and tubing parts which do not require the tensile strength provided by copper or brass.

Coils and Bends

Our manufacturing department is well equipped for coiling and bending seamless copper and brass tubing in sizes—from $\frac{1}{16}$ to $1\frac{1}{2}$ in. O. D.

Organized for quantity production, we also offer unusual facilities and the cooperation of an efficient engineering department toward the improvement in design of parts made of seamless tubing.

Coils and bends of copper and brass are made without flattening, tested up to 250 lb. and delivered free from discoloration—inside and outside.

Castings and fittings may be furnished and coils or bent tubing parts delivered complete. Silver solder is used exclusively because of its many superior qualities in brazing.

The Modern 5-acre Mill of the Wolverine Tube Co., Detroit, Michigan

York Heating and Ventilating Corp.

York Building, 16th and Sansom Streets **Philadelphia**

Branch Offices and Representatives in All Principal Cities

York Super-Fin Extended Surface Copper Indirect Radiation for Central Blast Systems

YORK
SUPER-FIN
UNIT

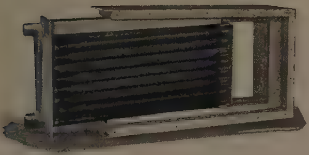


Fig. 1. By removing a few bolts, the Super-Fin coil may be withdrawn from its casing.

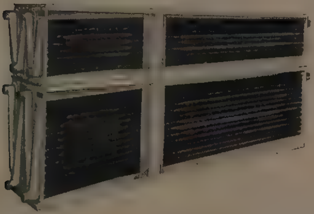


Fig. 2. In this assembly are four sizes of Super-Fin, illustrating that innumerable combinations can be made, to give any required face area. Note: *The Supply and return are at the same end, permitting end-to-end stacking.*

High or Low Pressure—

York Super-Fin is made in one type only, equally suitable for high or low pressure service. It is tested at 1000 lb. hydrostatic pressure and guaranteed for any working pressure up to 200 lb.

Design—

A helical copper fin is actually imbedded in the heavy copper tube. The fin is perfectly smooth, without crimping. Tubes are U-shaped, and are fused into the headers. Supply and return are at the same end. Each Super-Fin unit is in a galvanized casing from which it may easily be withdrawn by loosening the bolts at one end.

Advantages—

(1) Three-side contact and bond between fin and tube. (2) *No joints to leak—every tube fused into header.* (3) High test pressure is assurance of durability under severe conditions including ordinary water hammer. (4) Supply and return at same end simplifies stacking and piping connections. (Can be set end-to-end). (5) Removable from casing. Makes cleaning easy. (6) Smooth fin without crimping minimizes dirt collection and makes cleaning easier. (7) U-tube construction eliminates strains from expansion and contraction. (8) Drainage pitch in tubes permits casing to be level. (9) Cuts cost of installation by its easy handling and adaptability.

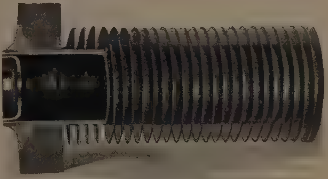


Fig. 3. Note fusion of tube and header plate. There are no joints to leak. Copper orifice ring gives equal steam distribution to all tubes. Fin imbedded in tube gives 3-side contact.

Sizes—

The range of sizes enables Super-Fin to fit any condition. There are 1, 2, 3 or 4 nominal depths of tubes in one casing. Casings are 10 in. thick, several heights and lengths.

TABLE OF FACE AREAS IN SQ. FT.

Height of Section		Length of Casing			
Symbol	Dimension	32″	42″	62″	82″
A	17″	2.0	2.5	4.0	5.5
N	23″	3.0	4.0	6.5	9.0
U	29″	4.0	5.5	8.5	12.0
W	35″	5.0	7.0	11.0	15.0

Note: In specifying Super-Fin sections add to the size designation the number of rows in depth required—i.e.

N42-1 means a section 23 in. high, 42 in. long, having 4 sq. ft. face area, one row deep. Similarly, W82-4 means a section 35 in. high, 82 in. long with 15 sq. ft. of face area, four rows in depth.

Complete rating catalog on request

D. & T. Manufacturing Company

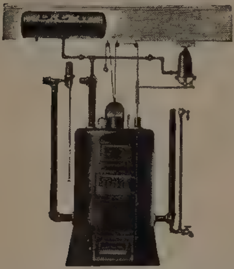
Factory and Engineering Dept.
3001-3009 La Salle Street
St. Louis, Mo.

General Sales Office
15-17 South Clinton Street
Chicago, Ill.

Pioneer Manufacturers
AUTOMATIC HOT WATER HEATING SPECIALTIES

The Complete Line

D. & T. System



The original Tank-in-Basement Self-Regulated Hot Water Heating System. Economical, efficient and durable.

All-In-One System

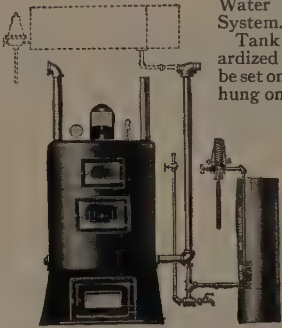
A reliable, low cost, self-contained, Closed System with special and exclusive features including an Emergency Relief Device.

Operates entirely automatic either without or with Expansion Tank.

Simplex System

Lowest cost, dependable, Air-Sealed Hot Water Heating System.

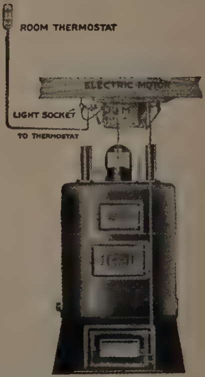
Tank is standardized and may be set on Floor or hung on Ceiling.



J. M. Electric Temperature Regulator

A guaranteed Heat Regulator and fuel saver sold at a popular price.

Underwriters' Laboratories approved.



Combined Catalog and Text Book

The D. & T. Combined Text Book and Catalog, "Progress in Hot Water Heating," in addition to listing, describing and illustrating our complete line of Automatic Systems and Specialties for Hot Water Heating also

Includes 50 Pages of Useful Data

design and standard practice detail, as substantiated and enthusiastically endorsed also by A. S. H. & V. E.

Write Today for Your Copy

Kainer & Company

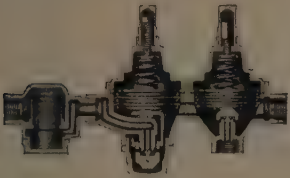
761-771 Mather Street, **Chicago, Ill.**

KAINER SPECIALTIES

For Hot Water Heating Systems

Entirely Automatic Heat Control

Any ordinary gravity hot water job, old or new, equipped with the Kainer Pressure Governor, Kainer Sylphon Hot Water Damper Regulator, and Kainer Pressure Gauge, gives an entirely automatic and fully closed system that maintains uniform room temperatures by controlling the water temperature, effects marked fuel economy and lengthens the interval between firing periods.



The Kainer Pressure Governor

The Kainer Pressure Governor is a simple, safe and accurate device for pressure reducing and relief service on any hot water heating system, old or new. It is comprised of two automatic valve units (cast integral) and a filter. One valve unit reduces and governs the water supply; the other valve unit relieves the heating system when excessive pressure due to expansion develops.

Full flow opening in the reducing unit permits very quick filling of the system when first installed.

The Kainer Bellows Diaphragm is used on both valve units. It contains no material requiring service or replacement.

The entire governor is of cast or phosphor bronze—rust-proof, scale-proof and trouble-proof. It can be instantly disassembled for inspection.

The Governor is tested at 60 lb. pressure and set at the factory to maintain 10 lb. on the system and to relieve the system when the pressure due to expansion reaches 30 lb.

List price Kainer Pressure Governor, complete with instructions for mounting $24.00

The Kainer Pressure Relief Valve

Furnished in two models. For use on domestic range boilers and Hot Water Heating Systems.

Model A is factory adjusted to operate at 30 lb. pressure.

Model B is furnished to relieve at pressures of 50, 75, 100 and 130 lb. to your specifications.

List Price, either model, $7.50.

The Kainer Pressure Reducing Valve

Used principally on old or new hot water systems consisting of tank and relief valve only. Installing the Kainer Pressure Reducing Valve makes the system fully automatic.

The Kainer Pressure Reducing Valve can also be installed with a Kainer Relief Valve and filter thereby making a manually filled system entirely automatic.

List Price, $12.00

The Kainer Filter

We strongly recommend the use of this filter when installing our reducing and relief valves.

The rugged filter screen of perforated copper strains the water and prevents particles of rust, dirt and scale from fouling valve seats, insuring continuous trouble-free operation.

List Price, $3.00

The Kainer Sylphon Regulator

Furnished complete with trimmings. When ordering ask for Kainer Sylphon Damper Regulator 46-WK. List Price, $16.00

The Kainer Pressure Gauge

3½ in. dial calibrated to 60 lb. White enamel finish.

List Price, $2.50

MUELLER CO.

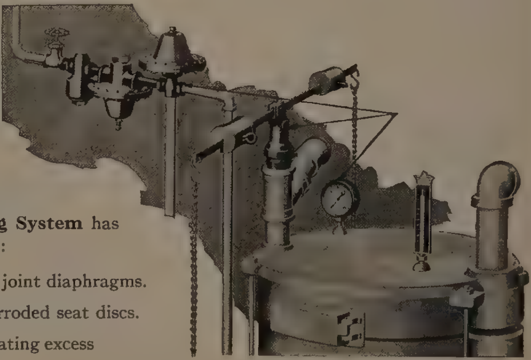
Decatur, Ill.

Branches

New York, Los Angeles, San Francisco, Dallas, Atlanta

PRODUCTS—Mueller Heating System.
Reducing and Regulating Valves for water.
Reducing and Regulating Valves for Steam.
Relief Valves. Water Strainers.

A Complete Line of Plumbing and Gas Brass Goods



The Mueller Heating System—has won favor wherever it has been installed. It is a closed system operating automatically without an expansion tank.

The Mueller Heating System has 9 Points of Superiority:

1. No rubber or solder joint diaphragms.
2. No soft or easily corroded seat discs.
3. No possibility of creating excess pressure.
4. No sediment or lime collecting pockets.
5. No complicated valve mechanisms.
6. No corrosive metal working parts.
7. No close fitting guides or guide wings.
8. No working parts which cannot be easily replaced.
9. **The Big Red Mueller Heating System** is designed correctly with proper diaphragm area for long dependable service.

The Mueller Heating System has no expansion tank, costs no more and is easier to operate. Water in the system is always fresh. The system saves fuel owing to its automatic supply, relief, and damper regulation.

Reducing and Regulating Valves—For steam, water, air, gas and oil.

Plumbing Bronze—Faucets, stops, etc., for kitchen, bath and laboratory.

Gas Brass Goods—A complete line of stops, meter hangers, etc.

Mueller Co.—Established in 1857, is rounding out its 73rd year of manufacture of quality brass goods.

Specific information regarding any Mueller product gladly furnished on request.

Neptune Meter Company

50 East 42nd Street
New York, N. Y.

Branch Offices

Atlanta, Ga.....254 Spring St., N.W.
Chicago, Ill.....130 N. Jefferson St.
Dallas, Tex.....2014 Commerce St.
Denver, Colo..............1700–15th St.
Los Angeles, Calif., 701 E. Third St.
Louisville, Ky.....815 W. Market St.
Portland, Ore..................474 Glisan St.
San Francisco, Calif., 320 Market St.
Thomson Meter Corp......375 Fulton St., Brooklyn, N. Y.
Neptune Meter Co., Ltd., 345 Sorauren Ave., Tronto, Ont.

Distributors

J. L. Stulsaft..........501 Fifth Ave., New York City, N. Y.
Richardson & Boynton....1308 Arch St., Philadelphia, Pa.
Walsh & Charles..........406 Tribune Bldg., Winnipeg, Man.
Gordon & Belyea, Ltd., 101 Powell St., Vancouver, B. C.
James Robertson Co., Ltd...............................St. John N. B.

PRODUCTS—Red Top Relief Valve, Model No. 2, the basis of your own closed hot water heating system, and for protecting hot water heating systems against boiler explosions, cracked boiler sections, and other ruptures.

Red Top Relief Valve, Model No. 1, for protecting range boilers, tank heaters, piping and fixtures in domestic hot water supply systems against dangerous pressures.

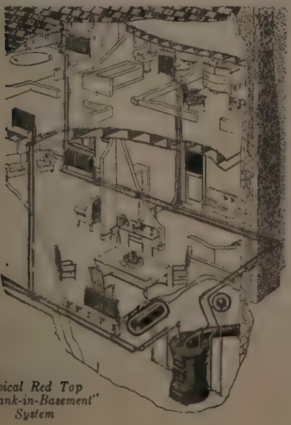
Red Top "Tank-in-Basement" (or Pressure System) of Hot Water Heating

A No. 2 Red Top Relief Valve, and *any air-tight tank of good make* are the *only two special parts* required for the most efficient, low-cost system of hot water heating.

The illustration shows a typical Red Top System in a two story residence. The air-tight tank—which gives a cushioning effect that promotes rapid circulation—is placed in the basement where it belongs. Since the hot water circulation is more rapid, smaller piping and less radiation surface may be used.

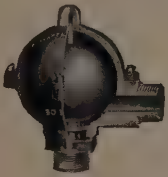
For a "closed" system the following sizes of air-tight expansion tank are suggested:

Up to 500 ft. rad., 15 gal. tank 12 in. diam. x 30 in. long
500 to 800 ft. rad., 21 gal. tank 12 in. diam. x 42 in. long
800 to 1200 ft. rad., 26 gal. tank 12 in. diam. x 54 in. long
1200 to 1600 ft. rad., 42 gal. tank ___ diam. ___ long



Typical Red Top "Tank-in-Basement" System

Red Top "Tank-in-Basement" Systems Offer These Advantages:



Sectional View, Model No. 2, Red Top Relief Valve

1. No more cracked boiler sections or other costly ruptures due to excessive pressures.
2. No more frozen overflow pipes, or corroded and clogged expansion tank outlets.
3. More efficient heating due to faster circulation of hot water—twice as fast as in old type overhead gravity systems.
4. Water, returning to the boiler at a higher temperature, requires less reheating.
5. Fuel is saved—frequently as much as 20%.
6. Less firing—saving labor.
7. Expansion tank is in basement. It does not take up usable space in some other part of house.
8. No waste of water from system. No water can leave until the pressure reaches the danger point, when water is automatically released by the Red Top Relief Valve.
9. Very moderate in cost. Easily applied when the heating plant is installed.
10. Old systems can be changed over to the Red Top with little trouble and small cost.
11. First, last and *always* a *safe* system—protecting property and life from dangerous rising pressures.

Approved by Underwriters

Red Top Relief Valves, both Model No. 1 and No. 2, are approved by the Underwriters' Laboratories, and by state and municipal bureaus of water and boiler inspection.

Red Top Relief Valves act on the dead weight or gravity principle. In Model No. 2, a special nickel weighted piston is lifted off its seat when pressure reaches 30 lb. Non-corrosive metal is used throughout. No springs, levers, diaphragms or other complicated parts to get out of order. Made for either "open" or "closed" systems. Model No. 2 is 6½ in. high, 5¾ in. wide, with inlet and male outlet threaded for standard 1 in. fittings.

Model No. 1 For Domestic Hot Water Supply

Protects domestic hot water supply and prevents range boiler explosions and other ruptures. Made with inlet threaded for standard ½ in. pipe fitting and outlet drilled and tapped for ½ in. connection. May be adjusted to relieve automatically at 50, 75, 100 and 130 lb. pressure. Model No. 1 is 4½ in. high and 4 in. wide.

Model No. 1, Red Top Relief Valve

Thrush
Differential
Pressure
Relief

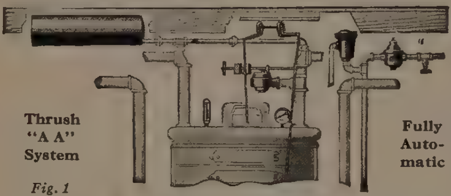
Automatic
Dual Control
Unit

H. A. Thrush & Company

Makers of Thrush Systems
Factory and Offices
Peru, Ind.

Thrush
Electric Water
Circulator

Thrush
Automatic
Damper
Regulator



Thrush
"A A"
System

Fully
Automatic

Fig. 1

Thrush System comprises equipment to be added to any unregulated gravity Hot Water Heating plant to make it a "Closed System" operating under additional pressure and with automatic control of dampers. It increases heat transmission and reduces fuel consumption. It is made in four types as listed below.

DATA and SPECIFICATIONS

Class AA Equipment consists of Thrush Differential Pressure Relief Valve, Automatic Temperature Damper Regulator, Pressure Reducing Valve, Copper Bearing Steel Pressure Tank and special Gauge and Thermometer. It is automatic filling.

Class A Equipment

This is the same as Class AA Equipment except that it has no Pressure Reducing Valve for automatic filling.

Class BB Equipment

Consists of Thrush Differential Pressure Relief, Pressure Reducing Valve, Copper Bearing Steel Pressure Tank and special Gauge and Thermometer. It is automatic filling.

Class B Equipment

Same as above except that it does not have Pressure Reducing Valve for automatic filling.

Sizes

Size No. 0 up to 350 sq. ft. of radiation
Size No. 1 up to 700 sq. ft. of radiation
Size No. 2 up to 1200 sq. ft. of radiation
Size No. 3 up to 2000 sq. ft. of radiation

Automatic Dual Control Unit

An inexpensive heating system for competitive job. The Automatic Dual Control Unit may be used for small to medium sized hot water heating plants, easily and economically, by merely installing the Dual Control Unit in the water supply line. Furnished with or without strainer, as desired.

Fig. 2

Thrush Differential Pressure Relief

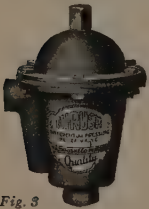


Fig. 3

This valve is designed with large valve area and has a capacity for relieving excess pressure for both large and small installations. The valve seat is submerged in water, so designed that corrosion or sediment accumulation is prevented. It is always Safe. (Tapping ¾ in.).

Thrush Automatic Temperature Damper Regulator

The operation of this Regulator depends upon the temperature change of the water circulating through the heating system and not upon pressure. Easily installed and very efficient. (Tapping 1½ in.).

Fig. 4

Thrush Electric Circulator

Here is a method of assuring positive circulation on any Hot Water Heating job. The Thrush Electric Circulator will pay for itself in less than one season in fuel saving.

Highly recommended for oil and gas fired boilers, also for greenhouses, garages, apartments, store buildings, works perfectly with blower units. Cheaper to install than low pressure steam, vapor or vacuum vapor jobs. 110 or 220 A.C. 60 cycle motor for light or power line. Low operating cost. Any type motor shipped from stock.

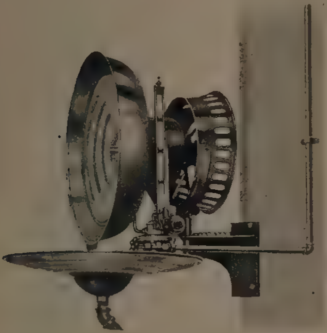
Tapping	Gallons Capacity	Radiation Capacity	Price
No. 22—2 inch	30 per minute	2500 sq. ft.	$131.25
No. 23—3 inch	70 per minute	6000 sq. ft.	150.00

Fig. 5

The Bahnson Company

BAHNSON HUMIDIFIERS

Winston-Salem, N. C.



The Bahnson Humidiffer

Bahnson Humidifiers are individual, self-contained humidifying units. In operation water is fed near the center of a revolving disk from the rim of which it flows off and strikes a series of stationary teeth surrounding the rim of the disk. A fan mounted on the end of the motor shaft opposite the disk carries out into the air of the room all particles of water which are fine enough to float in the air. This fan also provides the proper degree of air movement for thorough moisture distribution.

The speed of the disk is such that when the water leaves the rim of the disk it strikes the teeth with an impact corresponding to the speeding velocity at approximately 110 lb. pressure.

Due to the method of producing finely-divided water particles, the amount evaporated by each unit may be varied without sacrificing efficiency, the percentage of feed water evaporated being practically constant throughout the range of the unit. The actual amount evaporated is around 50 lb. per hour under average conditions, and may be increased to 75 or more pounds under particularly favorable conditions or may have to be materially reduced in rooms where ceilings are low or where there is a large amount of machinery or belting or shafting. Each unit is equipped with an individual automatic humidity control which operates to increase or decrease the amount of water fed to the machine in accordance with the conditions of the air around it. This control will hold the humidity condition uniform within plus or minus 5 per cent variation.

Power required is approximately 200 watts per unit for 3-phase, 60-cycle, 110 or 220 volt motors. Single-phase motors require 225 to 230 watts. On account of the unavoidably low-power factor and efficiency of all small motors, allow one KVA of transformer capacity to each 3 single-phase or 4 polyphase units. All motors are mechanically interchangeable.

The Bahnson Master Control

The Bahnson Master Control has been developed to give a sensitive and accurate instrument to open or close a valve in response to changes in relative humidity of the air. Bahnson Master Controls are adjusted at the factory and the mechanism is then sealed in a glass tube case. Changes in humidity may be obtained by a regulating screw, whereby the humidity may be raised or lowered as much as 10 per cent either way from normal setting.

For ordinary commercial use the Master Control is set to operate on a variation of relative humidity of 1 per cent between high and low. Where the instrument is to be used for laboratory purposes it may be set to operate on changes of relative humidity within average reading error of the ordinary sling psychrometer. The expansive element used which is of specially prepared vegetable fiber is extremely rapid in its response to changes in atmospheric humidity and has been proven to hold a constant humidity through wide variations of Temperature. The control is entirely electrical in its action and may be located regardless of the location of the valve. Each control is a unit and is connected up with a three-wire polarised attachment plug to a properly-wired electrical valve. Current is used only while the valve is opening or closing, and is taken from any 110 volt line through a 1 ampere fuse.

Consolidated Ashcroft Hancock Co., Inc.

Subsidiary of Manning, Maxwell and Moore, Inc.

Makers of AMERICAN INDUSTRIAL INSTRUMENTS—Since 1851

Bridgeport, Conn.

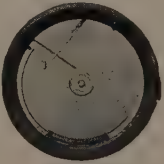
BRANCHES IN PRINCIPAL CITIES

Manufacturers of Indicating and Recording Gauges; Gauge Testers; "U" Gauges; Draft Gauges; Indicating and Recording Thermometers; Tachometers; Dial Thermometers; Pressure and Temperature Controllers; Electric Temperature Controllers; Pop Safety and Water Relief Valves; Steam Traps; Engine Indicators; Counters; Absolute Pressure Gauges.

Also manufacturers of Locomotive and Engine Room Clocks; Barometers; Mercury Column Gauges; Steam Whistles; Hydraulagraphs; Gauge Boards.

American Quality Gauges—American Quality Gauges are made in all sizes from 2½ to 12 in., for pressures from 10 to 30,000 lbs. and also for vacuum. Cases are cast iron or cast brass. The movements are Heavy Duty and all bearings are Monel Metal. Write for Catalog No. A-59.

For Mercury Pressure and Vacuum Gauges, "U" Gauges, Draft Gauges and Mercurial Barometers. Write for Catalog B-59.

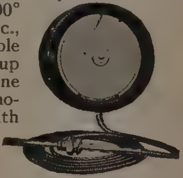


American Recording Gauges—American Recording Gauges are made for all pressures from 15 in. of water to 10,000 lbs. and for vacuum. They are made in one size only to accommodate a 10 in. chart, having an effective scale width of 3⅝ in. The case is Die Cast with a dull black hard-rubber finish and with either bottom or back connection. The pen-arm is made of non-corrosive Monel Metal and is of the inverted type. Operating instructions are lithographed on the chart plate so that they cannot be lost.

Especially designed Seth Thomas clocks are used, and all customary time periods can be furnished.

American Recording Gauges are equipped with the Time Punch which virtually makes each instrument a time clock, since a hole is punched in the chart whenever a reading is taken. Write for Catalog E-59.

American Air Duct Thermometer—Designed especially for both warm and cold air ducts. Fitted with polished brass or nickel plated "V" shaped case, glass front. Furnished with 9-in. or 12-in. scale graduated 0-160 ° F. Write for Catalog F-59.



American Recording Thermometers—American Recording Thermometers are made for recording all temperatures from minus 40 to plus 1000° F. or equivalent c., and with very flexible connecting tubing up to 200 ft. Made in one size only to accommodate 10 in. chart, with any effective scale width of 3⅝ in.

The case is the same as for the American Recording Gauge, so that all instruments are uniform in appearance when mounted on Gauge Boards. American Indicating Gauges and Dial Thermometers are also furnished in same case. Write for Catalog H-59.

American Dial Thermometers—American Dial (mercury-filled) Indicating Thermometer has the accuracy of the standard glass tube thermometer and the reading convenience of a dial face. Entire working mechanism is made of steel, meaning long life.

Standard size of dial 6 and 12 in. Furnished with either rigid connection or flexible capillary steel tubing up to 200 ft. long. Made for any temperature range from minus 40 to plus 1000° F. Write for Catalog G-59.

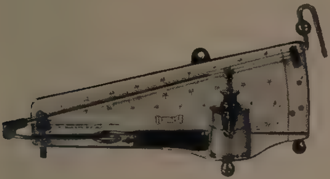
American Automatic Controllers—A complete line of American Controllers for automatically controlling pressure, vacuum, temperature, condensation, humidity liquid levels, timing of processes, control of dampers, etc. Write for Catalog R-59.

American Pop Safety and Water Relief Valves—Safety Valves of brass and iron for any set pressure up to 300 lbs., and of cast steel with outside spring up to 400 lbs. Relief Valves of bronze and iron for pressures up to 10,000 lbs. Write for Catalogs U-59 and V-59.

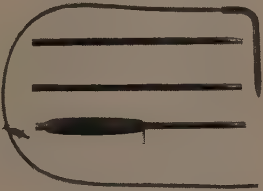
E. VERNON HILL Co
AEROLOGISTS

121 North Clark Street Chicago, Ill.

Manufacturers of TELTRU Instruments for Air Testing



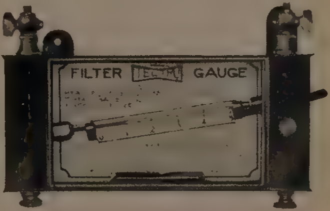
TELTRU MANOMETER



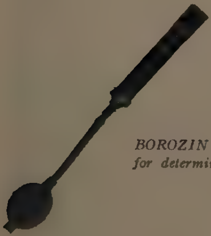
JOINTED PITOT TUBE

The standard portable pitot tube and gauge outfit for measuring pressures.

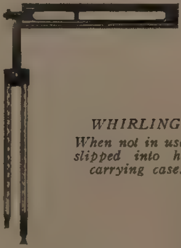
TELTRU SLANT GAUGE
for chimney draft determinations. Range 0 to 2 in. of water



TELTRU FILTER GAUGE
for permanent mounting for indicating resistance thru air filters



BOROZIN A. C. MACHINE
for determining behavior of air currents



WHIRLING PSYCHROMETER
When not in use thermometers are slipped into handle which serves as carrying case. Fits in vest pocket.

TRADE TELTRU MARK

A TRADE MARK WITH A MEANING

The Palmer Company

MANUFACTURERS

426 Clay Street, **Cincinnati, (St. Bernard) Ohio**

Industrial Indicating Thermometers:

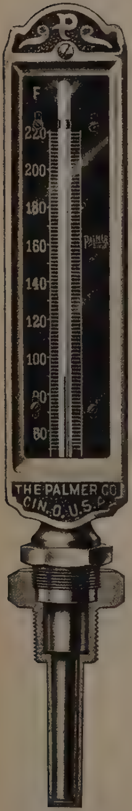
Made in three standard case sizes:
12 in., 9 in. and 7 in. (as illustrated).

FORMS:

Straight,
90 deg. Angle,
Reclining and Inclining case styles,
Right and Left Side Angle styles.

FITTINGS:

Plain shank;
Fixed flange;
Adjustable flange (movable on stem);
Adjustable clamp hook;
Fixed taper thread;
Flanged Union connection;
Union connection;
Separable Socket (as illustrated);
Parallel thread fitting with locknut (for rooms, ovens, etc.).
Insulation between case and stem (for frost, etc.)
Extension neck (stem to pass through pipe covering, etc.)
Standard stem length: 3½ in.; other lengths can be ordered.
Standard ranges: −20 +120°F.; +40 +240°F.; 0 +100°F.; +30 +180°F.; +170 +270°F. & P.; +30 +300°F.; +50 +400°F.; +200 +400°F.; +200 +550°F.; +200 +750°F. Other ranges can be furnished.



Illustrating 7 in. case Straight style; with Separable Socket connection.

Construction:

Lens, mercury tube; large diameter glass, easily read;
Graduated brass scale; large numbers;
V-shaped case; Glass front protection over tube;
All tubes annealed to prevent change with age;
Accuracy Guaranteed on every thermometer;
For registering air temperatures, the bulb is bare and protected by a perforated metal stem around bulb;
For liquids, a mercury chamber is furnished around bulb;
Extra guards can be supplied with thermometer for protection to the bulb.

Laboratory and Test Thermometers:

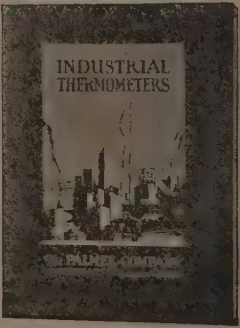
Chemical type, all glass thermometers, with lines and numbers engraved on the glass tube;
Furnished in various lengths and ranges suitable for making tests, etc.;
Pocket style chemical thermometer is enclosed in metal case for use of service men, etc.

New Catalog:

Write for your copy of our new 68-page catalog, illustrating all types of thermometers.

Additional copies furnished to Department Heads upon request.

The ONLY thermometer Catalog like this in the field! Each thermometer is illustrated and fully described. Prices shown at each thermometer listed. *Send for this today!*



INDUSTRIAL THERMOMETERS

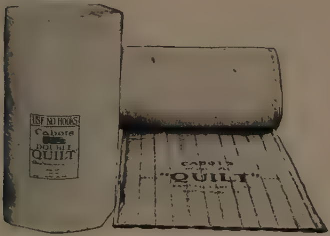
141 Milk Street **Samuel Cabot** *Incorporated* **Boston, Mass.**

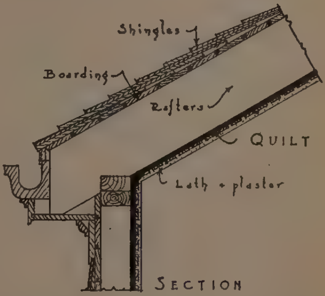
101 Park Avenue, New York
5000 Bloomingdale Avenue, Chicago

Philadelphia, Kansas City, Minneapolis, Los Angeles, San Francisco, Seattle, Portland

Cabot's Heat-Insulating Quilt (Trade Mark)

Cabot's Quilt is the original flexible insulator. It is made in three thicknesses—single, double and triple—is 36 in. wide and shipped in rolls covering 250 sq. ft. each. **Quilt** is made of Zostera Marina, gathered on the Bay of Fundy, and will not rot, will not burn and will not harbor insects or vermin.





Quilt *Insulation in Roof and Wall Construction*

U. S. Government Bureau of Standards Letter Circular No. 227, reporting tests of numerous Insulating Materials, gives **Cabot's quilt** a Thermal Conductivity rating of 0.25 which was equalled by only two other insulators, regardless of cost.

Tests conducted by Prof. Gordon B. Wilkes, of the Massachusetts Institute of Technology, show the following savings in heat leakage in different methods of construction, by the use of **Cabot's Quilt.**

CONSTRUCTION WALL	Conductivity Uninsulated "H"	Conductivity Insulated with Cabot's Double Ply Quilt—"H¹"	Percentage Heat Saving
Clapboard, studding	0.70	0.26	63
Clapboard, studding, lath, plaster	0.44	0.21	52
Clapboard, sheathing, studding, lath, plaster	0.28	0.16	43
8 in. brick	0.40	0.20	50
8 in. brick, furring, lath, plaster	0.27	0.16	41
4 in. tile, stucco, outside, plaster inside	0.40	0.20	50
12 in. concrete	0.46	0.21	54
Corrugated iron	1.50	0.32	79
12 in. stone	0.49	0.22	55
12 in. concrete, furring, lath, plaster	0.40	0.20	50
Stucco, studding, plaster	0.45	0.21	53

ROOF			
Tar, gravel on 4 in. concrete	0.60	0.24	60
Metal on tongue and groove sheathing	0.42	0.20	52
Corrugated iron on wood frame	1.80	0.32	82
Tile or slate on wood sheathing	0.82	0.27	67
Tar, gravel, tar paper, 2 in. wood plank	0.26	0.16	39
Shingles, sheathing, studding, lath, plaster	0.30	0.17	43
Wood shingles on shingle lath	0.64*	0.24	63

*Average value from Jones' tables, *The Heating and Ventilating Magazine.*

The cost of **Cabot's Quilt** is so low, for material and application, that reduction in Heating Equipment more than pays for entire insulation. Thereafter there is a yearly fuel saving.

Fire-resistant: Quilt is a *real* fire-resistant. It will not smoulder or carry fire.

Will not Rot: **Quilt** will not rot. It will last as long as the building.

Flexible: **Quilt** will fit any surface, or around corners or jogs. Lowest labor cost.

Soundproof: **Quilt** has enormous and successful use in Soundproofing buildings.

Armstrong Cork & Insulation Company

Lancaster, Pa.

Offices

Albany
Atlanta
Birmingham
Boston
Buffalo
Charlotte, N.C.
Chicago
Cincinnati
Cleveland
Dallas
Denver
Detroit
Houston, Tex.
Jacksonville, Fla.
Kansas City
Memphis
Milwaukee
Minneapolis
New York
Pittsburgh
Rochester
St. Louis
Montreal, Que., Can.
Toronto 2, Ont., Can.
Armstrong Cork Company, Ltd., London, England

Representatives

Baltimore	John R. Livezey
Los Angeles	Gay Engineering Corp.
New Orleans	H. T. Steffee
Philadelphia	John R. Livezey
Portland	Gillen-Cole Co.
San Francisco	Van Fleet-Freear Co.
Seattle	D. E. Fryer & Co.
Spokane	D. E. Fryer & Co.
Tacoma	D. E. Fryer & Co.
Washington	John R. Livezey

Detailed information, samples, and descriptive literature may be obtained on application to any of these offices or representatives.

Something over 50 per cent of the heat supplied to an uninsulated residential building is lost by conduction and radiation through the walls and roofs. But when the house is insulated with the recommended thicknesses of Armstrong's Corkboard this loss is so materially reduced that it can be heated comfortably with a smaller plant and less fuel.

Reference is made to Chapter 2, Heat Losses from Buildings, and particularly to the tables on pages 35 to 59 which very clearly show the remarkable heat saving effect of adding 1½ or 2 in. of corkboard to standard wall and roof constructions. The reduction in heat loss amounts to from 50 to 75 per cent. This means that an adequate thickness of corkboard on walls and roof reduces the heat wastage, and, therefore, the heat requirements of the house, by 25 to 40 per cent.

Advantages of Insulation

These savings, calculated and theoretical, are fully confirmed by the actual experience of hundreds of home owners. Cork-insulated houses all over the country are being heated with smaller furnaces and boilers and radiation a third or more less than would otherwise be installed, also with a corresponding economy of fuel consumption.

Furthermore, cork-insulated houses are heated much more uniformly, have no *cold side* or rooms that are *hard to heat*, and are decidedly freer from drafts. The greater comfort and economy of the cork-lined house reacts directly to the benefit of the heating engineer or contractor, since it reflects credit on the efficiency of his plant and the value of his services. Furthermore, by taking advantage of the heat saving effected by the insulation, the contractor builds up an invaluable fund of good will for himself by pointing out the economies he is able to offer with the reduced size and cost of heater and radiation.

Roof Insulation

Similar economies are effected in industrial heating where, as a rule, the roof of the building only is insulated. One of the greatest heat losses is through the roof and its adequate insulation with Armstrong's Corkboard gives very positive results, decidedly to the advantage of both owner and contractor.

Thickness of Insulation

One point to be guarded against in basing calculations on the heat-saving value of insulation is the *thickness* in which the insulation is used. For residences, the insulation of exterior walls should be 1½ in. of Armstrong's Corkboard and for roofs or top-floor ceilings, 2 in. These thicknesses have been established as affording the maximum of comfort and economy per dollar of insulation investment. The transmission figures given in the tables on pages 35 to 59 are for these thicknesses and the values shown can be depended upon for estimating heating requirements.

For roofs of commercial and industrial buildings, the thickness varies with conditions. Not less than 1 in. should be used in any case, preferably 1½ or 2 in. Where there is high humidity inside the building and ceiling sweat, the conditions should be analyzed by a competent engineer to determine the thickness necessary to prevent condensation.

Armstrong's Corkboard

Armstrong's Corkboard has been the standard insulation in the industries for the past 25 years. Many millions of feet of it are in use in cold storage plants, refrigerators, refrigerator cars, and in other industrial rooms where temperature control is essential. Its dependability and permanence have been proved under all kinds of conditions.

Armstrong's Corkboard is composed of clean granules of pure cork, compressed and solidified by a baking process into firm, semi-rigid sheets of uniform quality. Armstrong's Corkboard is made in boards measuring 12 x 32 in. and 36 in., 1, 1½, 2, 3, 4, and 6 in. thick. It is obvious that with this range of sizes, any thickness required for house insulation or commercial roof insulation can be applied in a *single thickness* and therefore at a considerable saving in labor cost.

Armstrong's Corkboard is light in weight, about 0.8 lb. per square foot 1 in. thick. It can be easily erected in any type of construction, being applied in portland cement mortar against masonry walls, nailed to studs, joists, and rafters, and laid in asphalt or pitch on roof decks. Regular house plaster is applied directly on the corkboard without lath, and standard roofings laid over the cork in the same manner as on the roof deck.

Further Information

Complete specifications and detailed information will be found in the book, "The Insulation of Walls and Roofs with Armstrong's Corkboard," which will be mailed on request.

Illustrating Armstrong's Corkboard being applied on the underside of roof rafters in a residence.

The Celotex Company

Branches in
Principal Cities

General Office
919 North Michigan Avenue
Chicago, Illinois

Mill
New Orleans, La.

CELOTEX
BRAND
INSULATING CANE BOARD

Outstanding Features

High Insulating Value.
Tough and Durable.
Structural Strength.
Light in Weight.
Easily Worked with Tools.
Cheaply Installed.
Sound-Deadening Properties.
Undergoes No Physical or Chemical Change after Installation.
Reasonable in Price.
Protects against Dampness.

General Characteristics

CELOTEX Insulating Cane Board is a rigid insulation made from cane fibre and "felted" into a board form of insulation.

Because of its many unique physical properties, CELOTEX has a wide variety of uses. It has a conductivity of 0.33 B.t.u. per hour, per square foot, per deg. fahr., per inch of thickness, based on tests conducted at Armour Institute, and checked at other nationally recognized engineering laboratories. Thus, when installed in the proper thickness, it effectively reduces the passage of heat through any type of construction.

CELOTEX is highly resistant to the passage of sound, and in addition, is sound absorbent. It has considerable structural strength and can therefore be used in place of other materials for sheathing and for plaster base. CELOTEX is easily worked with tools, and economically installed. It is waterproofed in manufacture and is therefore moisture resistant.

CELOTEX Roof Insulation

For Industrial, Commercial and Apartment Buildings, the convenient size of CELOTEX Roof Insulation Board makes it easy to handle and install. It compresses less than 1¼ per cent under a load of 720 lb. per sq. ft. and therefore provides protection to the roof covering against puncture and other damage. Usually secured to wood roof decks by nailing, and to metal, concrete and gypsum decks by embedding in pitch or asphalt and protecting with the usual built-up roofing. Individual boards measure 2 ft. wide by 5 ft. long. Thickness approximately ½ in. and is also furnished in laminated thicknesses of 2 to 8 plies.

CELOTEX Standard Building Board

This product is used for wall sheathing and provides a more rigid wall than is obtained with ordinary construction materials. Any type of exterior finish can be used over CELOTEX Standard Building Board—wood siding, applied directly over the CELOTEX; shingles applied over furring; stucco, applied over approved

stucco base; or brick veneer applied with customary anchors nailed through the Celotex into the studs. Also used for attic lining and interior finish in its natural color, or it may be painted, stained or panelled. It is applied by nailing direct to studding, joists, rafters or furring strips and can readily be cut and fitted. Celotex Standard Building Board is made in big, strong boards 4 ft. wide, 7 to 12 ft. long, 7/16 in. and 7/8 in. thick.

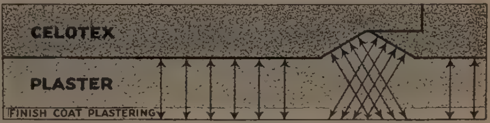
Acousti-Celotex

A highly efficient sound absorbing tile for acoustical correction and sound quieting. Is also very effective in reducing transmission of sound through ventilating ducts. Installed by approved contractors. Can be applied to any wall or ceiling surface and adopted to practically any style of decoration. Is permanent and can be easily cleaned whenever necessary.

Celotex Refrigerator Insulation Board

Made especially for insulating household and commercial refrigerators using ice or mechanical refrigeration, for ice storage houses, fruit storage and ripening rooms, and similar structures, also for railroad refrigerator and steel passenger cars. High insulating efficiency, strong, light in weight and rigid; easy to apply, clean, sterilized and odorless. Furnished in thicknesses of 1/2 in. and in laminated thicknesses of 2 to 8 plies and in any size piece required.

Celotex Lath

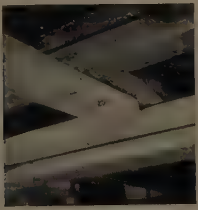


Celotex Lath is an excellent plaster base. The beveled edges and shiplapped joints reinforce against plaster cracks and eliminate lath marks. Plaster bonds with Celotex Lath with a strength of over 800 lb. per sq. ft. (See the illustration in which the arrows indicate the long line of reinforcement.)

The long, horizontal shiplapped joints of Celotex Lath make a strong, tight wall, as is indicated by the illustration. Furnished 18 in. wide, 48 in. long, 7/16 in. and 7/8 in. thick.

Celotex Industrial Insulation Board

May be obtained in a variety of lengths and thicknesses. Adapted to many non-structural insulation purposes, including air duct insulation, tank insulation, dry-kiln insulation, etc. Also used in place of tarpaulins to protect construction work during cold weather. Made 3 ft. wide by 6 ft. long.



Air Duct Insulation

Celotex Quickly Available

Celotex Standard Building Board and Celotex Lath are stocked by lumber dealers in every locality throughout the United States and Canada. This availability is a money-saving convenience in conducting construction work according to schedule.

Competent Engineering Service

The careful consideration of insulating requirements, invariably gives rise to situations demanding special study. As a means of simplifying this, The Celotex Company maintains an experienced engineering staff, which is available to Architects and Heating and Ventilating Engineers without cost.

Flax-li-num Insulating Company

Chicago Office
228 North La Salle

Home Office and Factory
St. Paul, Minnesota

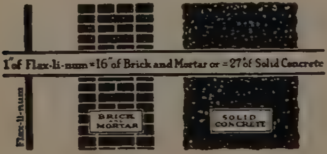
New York Office
ARCHITECTS BUILDING,
101 Park Avenue

Manufacturers of FLAX-LI-NUM

Flax-li-num is a thermal insulation and sound control material used for many years in various industries to meet existing insulation requirements. FLAX-LI-NUM is a semi-rigid board felted from the long tough fibres of the flax plant, consequently FLAX-LI-NUM is durable and assures the user that the insulation will last as long as the building stands.

Flax-li-num is vermin and rodent proof. It is guaranteed by the manufacturers never to fall down or become displaced in a building wall. As the material is of *semi-rigid* type it cannot warp, break or crack. FLAX-LI-NUM should not be considered as a substitute for ordinary wood or metal lath, sheathing or other parts of a building construction.

The FLAX-LI-NUM insulation method has been developed for roofs and walls of frame, brick, hollow tile or veneer constructions, and to give the user the full benefit of its heat insulation and sound proofing qualities.


1" of Flax-li-num = 16" of Brick and Mortar or = 27" of Solid Concrete
Flax-li-num
BRICK AND MORTAR
SOLID CONCRETE

Flax-li-num was introduced in 1909, first, to insulate railroad refrigerator cars, and has extended its application to a variety of insulating services in residences and industrial buildings and in many specialty markets, such as iceless shipping containers and kindred products.

The use of FLAX-LI-NUM in buildings, brings definite economies in fuel and radiation required, as well as the production and maintenance of healthful conditions. Heat transmission coefficients are given for various types of walls and roofs.

To get the best service from FLAX-LI-NUM, specify the exact place where insulation is to go. The effectiveness of insulation is increased if applied between studdings, midway between the sheathing and lath and plaster for frame construction, or furred out on masonry construction. FLAX-LI-NUM for walls should be at least ½ in. thick and for roofs 1 in. thick.

The FLAX-LI-NUM method of application of insulating material to all types of construction is fully covered in our booklet, "Heat Insulation for Houses"—A. I. A. File 37-b-1. There is also contained in this booklet the FLAX-LI-NUM radiation chart which greatly simplifies the accurate computation of radiation where heat loss factors are known. A copy of this publication should be in the files of every engineer and architect, and will be sent on request.

Heat Loss factors for various insulated and uninsulated walls of stucco, brick and frame construction are fully covered in the publication "Heat Insulation for Houses."

These walls are listed below with their *K* values, showing how these values are substantially reduced by the addition of FLAX-LI-NUM in accordance with our standard specification which calls for ½ in. FLAX-LI-NUM in side walls and 1 in. ceilings or roofs.

Stucco Walls

A-1.	Standard frame construction furred out over sheathing, metal lath and stucco. Lath and plaster inside	.242
B-1.	Same as above but with ½ in. Flax-li-num added	.146
C-1.	Standard frame construction with Byrkett sheathing. Stucco directly on sheathing. Lath and plaster inside	.287
D-1.	Same as above with ½ in. Flax-li-num added	.161
E-1.	Frame construction. Metal lath directly on studs. Stuccoed outside and back-plastered. Lath and plaster inside	.357
F-1.	Same as above with ½ in. Flax-li-num added	.181

Brick and Tile Walls

A-2.	Standard frame construction. Lath and plaster inside. Face brick veneer	.210
B-2.	Same as above with ½ in. Flax-li-num added	.133
C-2.	8 in. hollow tile. 4 in. Face Brick, plastered directly on tile	.255
D-2.	Same as above, but furred inside with 1 by 2 in., plastered on Flax-li-num Keyboard	.141
E-2.	Standard 13 in. solid brick wall, furred inside, lath and plaster	.191
F-2.	Same as above with Flax-li-num Keyboard as plaster base	.146

Frame Walls

A-3.	Standard frame construction. Sheathing, paper and siding outside. Lath and plaster inside	.255
B-3.	Same as above with ½ in. Flax-li-num added	.151
C-3.	Standard frame construction, same as A-3, except plastered on lumber substitute	.216
D-3.	Same as above with ½ in. Flax-li-num added	.136
E-3.	Standard frame construction, same as A-3, except lumber substitute used for sheathing	.229
F-3.	Same as above with ½ in. Flax-li-num added	.141

Roofs and Ceilings

A.	Standard frame construction. Wood shingles, attic floor. Lath and plaster	.179
B.	Same as above, with 1 in. Flax-li-num under ceiling joist furred down for lath and plaster	.104
C.	Standard frame construction, same as A, without attic floor.	.284
D.	Same as B, without attic floor.	.132
E.	Standard frame construction, attic floor, tile roof	.163
F.	Same as E, with 1 in. Flax-li-num under ceiling joist furred down for lath and plaster	.098

One of the fields in which FLAX-LI-NUM finds extensive use is in the insulation of industrial roofs, where it serves to reduce heat losses, secures greater comfort for workers and corrects condensation difficulties which hamper production in many instances. It is also extensively used for sound control and acoustical correction.

All details pertaining to the above uses are covered in the aforementioned publication, "Heat Insulation for Houses."

Chicago Mill & Lumber Corporation

111 West Washington Street, **Chicago, Ill.**

Weatherwood

INSULATES AGAINST UNFRIENDLY WEATHER

The Only Insulating Board Fabricated from Hardwood

PRODUCTS

WEATHERWOOD

Used as sheathing, roof, attic and floor insulation.

WEATHERWOOD LATH

Used as insulating plaster base.

Weatherwood is manufactured by fabricating weatherproofed hardwood fibers into boards of high tensile strength and high thermal insulating efficiency. Boards are uniformly full half-inch thick, 4 ft. wide by 8 to 12 ft. long. Weatherwood Lath are full half-inch thick, 18 in. by 48 in. Weight is approximately 650 pounds per thousand square feet.

Purposes—Approximately 50 per cent of the heat generated within an uninsulated structure is lost by conduction and radiation through walls and roof. It is estimated that 65 per cent of this lost heat passes through the roof and the remaining 35 per cent through walls and other points of escape. Weatherwood, used as sheathing, roof, floor and attic insulation, and as plaster base, will make remarkable heat savings in winter and prevent inward flow of heat in summer. Its effectiveness is so great as to add materially to the efficiency of the heating equipment you install. The Weatherwood Book on Industrial Construction, sent on request, provides valuable data including roof insulation and prevention of condensation.

Major Characteristics

1. Insulation Efficiency—The thermal conductivity of Weatherwood, 0.32 B.t.u. per hour per square foot per degree Fahrenheit per inch of thickness, demonstrated by laboratory tests, establishes an insulation efficiency unsurpassed by any other material of this character. All tests are by unbiased engineering authorities.

2. Strength—The natural toughness of hardwood fibers, and the process used to fabricate them into boards, gives Weatherwood strength and rigidity to provide great bracing strength in any of its structural uses.

3. Weatherproof—Special chemical treatment of the fibers during fabricating process weatherproofs the entire structure of Weatherwood. It resists surface damage from moisture and is practically nonabsorbent as well.

4. Sound Absorption—The thorough meshing of the hardwood fibers in the fabricating process provides Weatherwood with innumerable dead air cells, which afford a high efficiency in the absorption of sound.

5. Durability—Weatherwood is a durable, sterile, all-wood product. The character of the hardwood fiber and the sterilizing process in manufacture, insure a board that resists time and the elements, as well as a board which resists decay and the attacks of insects and rodents.

Samples and Information

Samples and the Weatherwood Book of Industrial Construction, with other information, will be sent on request. Technical information pertaining to Weatherwood, and assistance in the solving of individual problems are at your command. The cooperation of our engineering staff is available to heating engineers without cost or obligation.

The Insulite Company

INSULITE
the Wood-Fiber Insulating Board

Minneapolis, Minnesota

INSULITE
the Wood-Fiber Insulating Board

Offices

BOSTON
NEW YORK
PHILADELPHIA
WASHINGTON
CLEVELAND
DETROIT
CHICAGO
KANSAS CITY
LOS ANGELES

Representatives in All Principal Cities

Detailed information, samples, and literature may be obtained by application to any of the branch offices.

A Service Department is maintained for solution of your technical problems.

Insulite is an all-wood, rigid board insulation, used extensively for general building, plaster base, sound-deadening, acoustical, roof insulation and refrigerating purposes.

Insulite possesses durability, toughness, resilience, low thermal conductivity, high tensile strength and low capillarity and vapor absorption.

Insulite is used as sheathing, wallboard, plaster base and roof insulation in structures.

Insulite is an efficient sound deadener when used under machines and motors, or as air duct lining in heating and ventilation systems. Special wall and floor constructions using Insulite have marked sound deadening properties.

Insulite refrigeration material is a special low density, low capillarity and vapor absorption product, combining light weight with maximum insulation.

Insulite Building Board is obtainable in sheets full ½ in. thick, 4 ft. wide and 8 to 12 ft. long.

Insulite Plaster Base is made in ½ in. and 1 in. thicknesses 18 in. x 48 in. The ½ in. unit is shiplapped on the long edges to produce a wind tight joint. The 1 in. unit is made by offsetting two ½ in. straight sided pieces one inch on all four edges and stapling together with non-corroding wire.

Insulite Roof Insulation is obtainable in sheets 17 in. x 34 in., either ½ in. or 1 in. thick. The 1 in. unit is made by offsetting two ½ in. sheets one inch on all four edges and stapling together with non-corroding wire.

Insulite, cut to exact size, may be obtained for heating and ventilation work, or standard Insulite Building Board may be used.

Detailed information, samples and literature may be obtained by application to any of the branch offices.

A Service Department is maintained for solution of your technical problems.

International Fibre Board Limited

TEN/TEST
INSULATING BUILDING BOARD

Mills
Gatineau, Quebec
Canada

Sales Offices
1111 Beaver Hall Hill
Montreal
100 East 42nd Street
New York City

Mills
Midland, Ont.
Canada

Ten/Test is a manufactured lumber made from spruce fibres. These tough fibres are solidly pressed under a hydraulic pressure of 2,000 lb. per sq. in. into a strong homogeneous board 4 by 17 ft. **Ten/Test,** having a thickness of $^{15}/_{32}$ in., has a structural strength many times greater in wall section than $^{5}/_{8}$ in. horizontal pine sheathing. The fibres are chemically treated and water-proofed during process of manufacture until the insulation is non-hygroscopic, free from capillary attraction and moisture-resisting in service commensurate with the maximum degree of insulation obtainable.

Ten/Test Insulating Building Board is in no sense a laminated or semi-laminated structure. It has a smooth and even surface, creamy in color, and will readily take any interior finish.

Ten/Test's durability has been proved by twenty years of research, both in our own laboratory and under actual weather conditions.

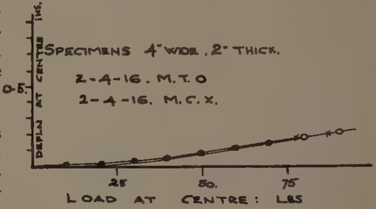
Official Tests

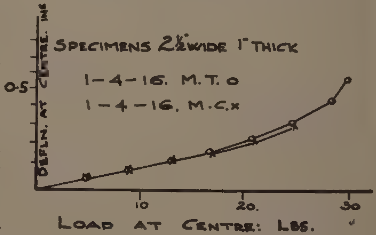
Conductivity. Ten/Test has a conductivity of 0.324 B.t.u. per hour per square foot per degree fahr. per 1 in. thick. Authority: Professor E. A. Allcut, M.Sc., M.I., Mech. E., Mem. A.S.M.E., Professor of Applied Mechanics, University of Toronto. Tests conducted under the hot plate method. Average temperature hot side 72.0 deg., cold side 32.9 deg. with average temperature difference of 39.1 deg. Mean Temperature 52.4 deg.

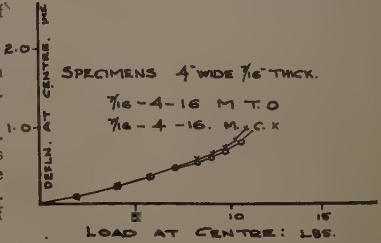
Tensile Strength 228 lb. per sq. in. Tests made on $^{7}/_{16}$ in. board cut to strips 1 in. wide and tested in a **Riehle Tensile Testing Machine,** the grips being 2 in. apart. 228 lb. is the mean average of series of seven tests.

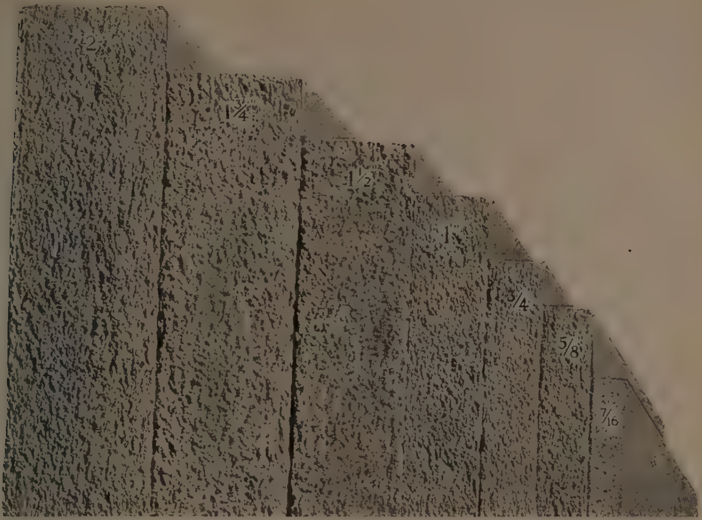
Transverse Strength, (equal deflection) is 28.4 lb. Test made on $^{7}/_{16}$ in. board, 6 in. wide, 18 in. long, on 12 in. centers, and load being applied to breaking point. For bending moment, see charts below.

The following charts show bending moment of Ten/Test under varying loads:









Plaster Bonding Strength. 1,340 lb. per sq. ft. Ordinary wood fibre plaster was applied to standard 7/16 in. board, and the pull was registered in an **Oslen Testing Machine.**

Moisture Resisting. Ten/Test, after complete immersion in water for 24 hours, registered 23.7 increase in weight. The water-proofing in the fibres is responsible for its resistance to moisture.

Sound Absorption. Coefficient of absorption of standard 7/16 in. **Ten/Test** is .35. The source of sound was a standard open organ pipe of 512 vibrations, operated from an electro-pneumatic wind chest, and time taken for absorption of the sound to limit of audibility was recorded by a torsion chronograph. Authority: Professor G. R. Anderson, Engineering Physics, Toronto University, Canada.

Note.—Authority for tensile strength, plaster bond, transverse and moisture tests; J. T. Donald & Co., Ltd., Chemical Analysts and Engineers, Montreal, Que.

Ten/Test Insulating Sheathing. For frame, drop or shingle siding, brick veneer or stucco construction, replacing wood sheathing. Made in convenient sizes—4 ft. wide and from 6 ft. to 17 ft. long.

Ten/Test Insulating Plaster Base. Any size **Ten/Test** sheet can be used for this purpose, but **Ten/Test** Notch Board is recommended for convenience of handling and elimination of plaster cracks. No metal lath is required over joints. Manufactured in small panels 16 by 47¾ in., with tongues and grooved interlocking joints.

Ten/Test Insulating Roof Boards. Manufactured in two sizes only—1 by 4 ft. and 2 by 4 ft. Quickly and easily applied in multiple layers and under any standard type of roofing. Approximately 28 lb. of asphalt or pitch required per 100 ft. for deck mopping.

Ten/Test Industrial Boards for Refrigerator and Cold Storage Insulation. Manufactured in any thickness from 7/16 to 2 in. thick and from 4 ft. wide up to 17 ft. long. Used for all purposes where an insulating material is required and temperature control demanded.

MACANDREWS & FORBES COMPANY

Business Established in U. S. A., 1870

200 FIFTH AVENUE, N. Y. FACTORY: CAMDEN, N. J.

MAFTEX

The "Thermal-Insulating" Board
that has Structural Strength

PRODUCTS:

MAFTEX STRUCTURAL INSULATING BOARD for sheathing, sound-proofing, etc.

MAFTEX ROOF INSULATING BOARD for flat roof decks.

MAF-LATH—the ideal plaster base.

MAFTEX REFRIGERATOR BOARD.

General Description:

MAFTEX—the four-in-one board that combines Insulation, Sheathing, Plaster Base and Sound Deadening—offers Heating and Ventilating Engineers definite advantages in structural strength, insulating efficiency and economy.

MAFTEX products are made from the roots of the licorice plant by a special process developed by the MacAndrews and Forbes Company. The thoroughly extracted, washed and sterlized root fibres are processed to produce a non-laminated board of great structural strength and remarkable thermal resistance.

Licorice root fibres are inherently resistant to attack by vermin and bacteria to an unusual degree. This natural characteristic together with the sterlization and chemical treatment incidental to processing MAFTEX insures permanence. An experimental board produced 20 years ago still retains its strength and other physical characteristics.

MAFTEX may be readily sawed, nailed or sandpapered. The sheets are strong enough to permit handling without danger of destroying the edges.

The ripple surface of MAFTEX not only furnishes an ideal base for gypsum plaster, but permits of unusual decorative effects when painted or stained.

Some MAFTEX Advantages:

Is highly moisture resisting, being made from licorice roots, a five-year subsoil growth.

Is a homogeneous mass of single-ply construction with millions of microscopic "dead-air" cells which effectively check the passage of heat and sound.

Has a thermal conductivity of 0.34.

Shows a savings up to 30 per cent on fuel bills, depending upon the type of construction.

Has a bonding strength with plaster of over 1,000 pounds per square foot.

Replaces wood sheathing and lathing with less cutting and less waste.

Retains its structural strength to the very edge, thereby eliminating danger of splitting and turning on corners.

Is easily sawed and nailed without waste.

Is completely sterilized, leaving nothing in the finished product to attract vermin or rats.

Is moisture proof, dry root proof and does not deteriorate with age.

Does not buckle, crack nor warp when properly applied.

Paints and stains produce beautiful effects on MAFTEX paneling applied to studs. If desired, the ripple surface itself forms an attractive finish.

Under floors and basement ceilings MAFTEX is used for its sound-absorbing qualities as well as for its insulating value.

MAFTEX Roof Insulating Board:

Due to its thickness MAFTEX ROOF INSULATING BOARD has an insulating value somewhat higher than Standard Structural MAFTEX and is intended for insulating purposes only. It is used on flat roofs to keep out the heat in summer, for saving of fuel in winter, and to prevent condensation.

Sizes of MAFTEX:

MAFTEX Structural Insulating Board is 7/16 in. in thickness, 4 ft. wide and 8, 9, 10 and 12 ft. long. Weight is approximately 750 lb. per 1,000 sq. ft.

MAFTEX Roof Insulating Board is made in 4 ft. by 4 ft. sheets, approximately ½ in. thickness.

MAF-LATH is cut in convenient size 16 x 48 in. for use by lathers as an insulating plaster base.

MAFTEX Refrigerator Board is cut to specified size for use by refrigerator and refrigerator car manufacturers.

Engineering Service:

Our Engineering Staff of Insulation specialists will gladly consult with engineers and architects and make any necessary experiments which might aid in solving thermal insulation problems.

Further Information:

We will be pleased to send a copy of the MAFTEX MANUAL—a practical and complete reference guide which clearly and concisely covers various phases of thermal insulation.

Masonite Corporation

111 W. Washington Street **Chicago, Ill.**

Masonite Structural Insulation and Masonite Presdwood

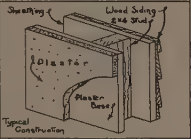
Pat. No. 1578609-1663503-1663504 1578609-1663505

Mills: LAUREL, MISS.

WOOD SIDING or CLAPBOARD WALLS

The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in B.t.u per Hr per Sq ft per 1° F.

Wood (Yellow Pine)	1.00 per 1"
Plaster (Gypsum)	2.32 per 1"
Wood Lath & Plaster	2.00 as app'd
Masonite Insulation (Board form)	0.321 per 1"



Type of Sheathing	Plaster Base	Coefficient of Transmission "U"
Wood	Wood Lath	0.222
Masonite Structural Insulation	Wood Lath	0.181
Wood	Masonite Structural Insulation	0.178
Masonite Structural Insulation	Masonite Structural Insulation	0.1576

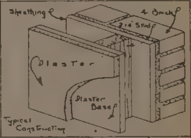
The great insulation value of Masonite is attributable to the cellular formation of the wood fibres from which it is made and to the thoroughness with which those fibres are felted together in the finished board. This also explains the great strength of Masonite Structural Insulation. This insulation is made entirely of fibres obtained by exploding fresh, clean wood chips and it contains no artificial binder of any character. There is nothing in Masonite to break down or disintegrate—it is permanent.

Masonite is used as sheathing on the outside of studs for both heat and sound insulation under wood siding, brick, stone or tile veneer and stucco. It is also used on the inside of studs as a plaster base—and it bonds with the plaster so effectively that an average pull of more than 1000 lb. is required to pull the plaster from one square foot of Masonite Insulating Lath.

BRICK VENEER WALLS

The values of U in the Table are based on the following Internal Conductivities (C) which are expressed in B.T.u per Hr per Sq.ft. per 1°F.

Brick	5.00 per 1"
Cement Mortar	8.00 per 1"
Plaster (Gypsum)	2.32 per 1"
Wood Lath & Plaster	2.00 as app'd
Masonite Insulation (Board form)	0.321 per 1"



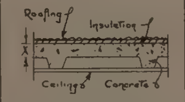
Type of Sheathing	Plaster Base	Coefficient of Transmission U
Wood	Wood Lath	0 216
Masonite Structural Insulation	Wood Lath	0 148
Wood	Masonite Structural Insulation	0 141
Masonite Structural Insulation	Masonite Structural Insulation	0 122

FLAT ROOF – METAL LATH & PLASTER CEILINGS

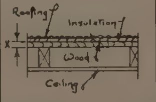
The values of U in this Table are based on the following Internal Conductivities (C) which are expressed in BTu per Hr per Sq ft per 1° F.

Roofing	1325 per 1"
Concrete	8.30 per 1"
Wood (Yellow Pine)	100 per 1"
Masonite Insulation (Brd Fm)	0.321 per 1"

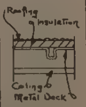
Concrete Roofs



Wood Roofs



Flat Metal Roof



Thickness of Insulation	Kind of Insulation	Concrete Roofs: Thickness of X						Wood Roofs: Thickness of X					Flat Metal Roof
		1⅝"	2"	3"	4"	5"	6"	1"	1½"	2"	3"	4"	
0"	No Insulation	305	.301	296	281	.271	.263	262	230	214	.177	.150	0.335
7/16"	Masonite Insulation (Board Form)	214	.212	207	.202	.197	.195	.192	.174	.165	.142	.124	0.228
7/8"		.165	163	.160	.158	155	152	151	.140	.134	.118	106	0 173

According to Professor F. B. Rowley, the conductivity of Masonite is 0.321

In roof decks, it effectively ends preventable heat losses and reduces condensation to a negligible minimum.

Pennrich & Company, Inc.

29 Broadway, **New York**

TORFOLEUM

MAILLIARD & SCHMIEDELL

LOS ANGELES SAN FRANCISCO PORTLAND SEATTLE VANCOUVER

Torfoleum is made of dried Sphagnum Moss and its record of performance under actual working conditions, over a period of years, has demonstrated conclusively that it is a highly efficient insulating sheet. Its nature and advantages make it of practical use in meeting a wide range of insulating and sound deadening needs.

Torfoleum has an exceptionally low thermal conductivity as confirmed by the test of J. C. Peebles of the Armour Institute of Technology:

Sample	Thickness In.	Density Lbs. Cu. Ft.	Mean Temp. Deg. Fahr.	Heat Conductivity, per 1 in. Thick	B.t.u. per Hour per Actual Thick.
1	1.62	10.7	70	0.253	0.156
2	1.61	11.4	70	0.266	0.165

Torfoleum has been rigidly tested for its resistance to compression and the compression in 1 in. under a load of 1,764 lb. per square foot in only 0.03 in.

Torfoleum does not rot. It contains no bituminous or mineral binder and therefore provides permanent insulation against heat and sound transmission.

Torfoleum is impregnated against water absorption which is a guaranty of the permanence of its insulating qualities.

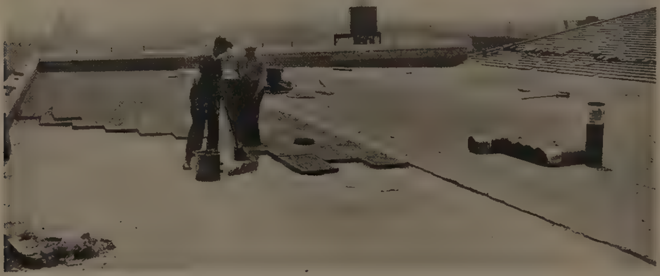
Torfoleum is free from harmful odor and particularly adaptable for use in storage plants where foodstuffs are to be stored.

Torfoleum is a sterile material.

Torfoleum is a fire retardant, as it has been thoroughly impregnated against rapid ignition and it may be used as a heat insulator up to 230 deg. fahr.

Torfoleum can be nailed and it can be cut with a knife or saw. Its application is very simple and can be done by anyone familiar with this type of work.

Torfoleum is made in sheets 12 by 32 in. or 19½ by 39 in., in thicknesses of 1, 1½, 2, 3, 4 and 6 in.; it is packed in cartons containing about 64 board feet and weighing approximately 70 lb.

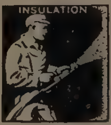


Applying 1½ in. Torfoleum to the Concrete Roof Slab of Addition to L. Bamberger & Co., Department Store, Newark, N. J., Jarvis Hunt, Chicago, Ill., Architect

Sprayo-Flake Company

Administrative Offices
Milwaukee

Manufacturers of
Sprayo-Flake
Material and Equipment



56 South Bay Street
Wisconsin

Licensed Operators
in Principal
Building Centers

INSULATION SPRAYED ON WITH GUNS

Process—Sprayo-Flake insulating process consists of forcing by air prepared flakes of fibrous material previously impregnated with fire resisting agent through a specially constructed gun. As the flakes leave the gun they are coated with sprays of atomized adhesive agent (water glass) or (asphalt) and projected to the surface to be insulated. The coated fibrous flakes form a blanket of insulation covering all cracks and crevices. It can be applied to practically any surface in any desired thickness.

Development—Sprayo-Flake was conceived by a layman while observing the installation of insulating material in his own home under course of construction. Prompted by a desire to overcome the inefficiency and attendant difficulties involved in installing prepared types of insulating materials, the spray-gun method was evolved. Further development proved the soundness of this theory. Sprayo-Flake method in one operation does a most thorough job; it eliminates entirely the labor of cutting, fitting, and nailing.

Further development of the original idea dates back to the year of 1924 when specially designed equipment was perfected to apply Sprayo-Flake. The next step was adoption of an adhesive agent, addition of fire resisting qualities, and vermin proofing which was perfected in laboratories and practical usage in the building field.

Distribution and Service—To assure the highest return per dollar invested in insulation the Sprayo-Flake Co. has adopted a modern, economically sound plan of merchandising and distribution. Sprayo-Flake is supplied direct from factory to job through licensed operators. These licensed operators located in principle building centers are insulation specialists, financially responsible, and work on an exclusive franchise basis. Each installation is made by expertly trained mechanics under exacting supervision.

This advanced plan of distribution enables the architect, builder, or owner to know the exact cost of insulation. Sprayo-Flake is always quoted on the basis of unit price per square foot or lump sum bid installed, including labor and material.

Physical Characteristics

The fibrous cellular structure and method of application gives Sprayo-Flake the desired characteristics of the ideal insulation material:

1. **LOW THERMAL CONDUCTIVITY.** 0.25 B.t.u. per hour per square foot per 1 in. thickness per degree temperature differential.
2. **PRACTICABILITY.** Can be applied to practically any surface in any desired thickness. Seals cracks and crevices, calks around window and door frames.
3. **FIRE RESISTANT.** Pre-chemically treated fibrous material plus the sodium silicate binder produces a highly effective fire resisting insulation.
4. **VERMIN PROOF.** Alkali silicate binder and alkaline sulphate asphalt impregnation render Sprayo-Flake insulation repellant to vermin.
5. **LIGHT WEIGHT.** Flakey fibrous air cell structure weighs only 4.6 lb. per cubic foot installed.
6. **PERMANENCY.** The fabricated blanket of Sprayo-Flake insulation is held in place securely by employing a sodium silicate and asphalt cohesive binder. This binder also preserves the fibrous flakes from deterioration. The cohesive and long-life properties of sodium silicate and asphalt have been recognized for years.
7. **LOW COST.** Sprayo-Flake insulation is manufactured and applied mechanically in one operation eliminating costly labor involved in cutting and fitting prepared types of materials.
8. **FLEXIBILITY.** Sprayo-Flake is sufficiently flexible to allow for usual expansion and contraction of structural members to which it is applied without impairing its efficiency.
9. **SOUND ABSORBENT.** The cellular structure and resiliency of Sprayo-Flake render it a highly sound absorbent material.

Note.—Conductivity and Transmission tests by such authorities as Prof. J. C. Peebles, Armour Institute Bureau of Standards and Prof. F. B. Rowley of Minneapolis.

Complete Technical Data and Specifications Furnished upon Request

Wood Conversion Company

General Office and Factory at

Cloquet, Minnesota

Manufacturers of

BalsamWool Blanket

District Sales Offices

CHICAGO, ILL.............1320 London Guaranty Bldg.
DETROIT, MICH.........................515 Stephenson Bldg.
KANSAS CITY, MO.........................231 West 47th St.
NEW YORK, N. Y.........................3107 Chanin Bldg.
MINNEAPOLIS, MINN.........................414 Baker Bldg.
SEATTLE, WASH.................................621 Ligget Bldg.
WASHINGTON, D. C.........................531 14th St. N. W.

Also Mfgrs. of NU-WOOD the All-Wood Insulating Wall Board and Lath

BALSAM-WOOL Standard Building Insulation is a flexible insulating blanket made from pure wood fibers in fleecy wool form, permanently matted together between two sheets of asphalt-coated, tough, flexible, creped Kraft paper. These patented crepe paper liners are capable of 25 per cent stretch which makes them virtually puncture proof, and the fact that these liners are not stitched renders BALSAM-WOOL windproof and waterproof. In the process of manufacture, BALSAM-WOOL is chemically treated to make it fire resistant, vermin and rot proof. It is clean, odorless and sanitary—a Weyerhaeuser product.

Sizes—BALSAM-WOOL for building insulation comes in three standard widths, 17, 25 and 33 in. and in two standard thicknesses, ½ and full inch. It comes rolled, wrapped and sealed. ½ in. BALSAM-WOOL weighs 240 lb. per 1,000 sq. ft., and full inch BALSAM-WOOL weighs 370 lb. per 1,000 sq. ft.

Application—In frame construction, BALSAM-WOOL 17 and 25 in. wide is applied between the studding, joists or roof rafters, flanged in the air space between sheathing and plaster. BALSAM-WOOL 33 in. wide is applied to the inside face of the studding or joists with furred out lath and plaster. In solid masonry construction, 17 or 25 in. BALSAM-WOOL is applied by flanging between furring strips 16 or 24 in. on center. 33 in. BALSAM-WOOL is applied with either single or double furring strips.

Test Results

Hot Plate Method

Material	Mean Temp. Deg. Fahr.	Thermal Conductivity per Hour	Authority
Balsam-Wool...........	70	0.246	Peebles
Balsam-Wool...........	90	0.27	Bureau of Standards

Hot Box Method

Description	Mean Temp. Deg. Fahr.	Heat Transmission Factor *U*	Authority
*3/8″ Wood Lath and 3/8″ Plaster, 3/4″ fir sheathing, building paper, 4″ lap siding, insulation "C," flanged midway in air space between studding.	40.2	0.115	Rowley

Efficiency—BALSAM-WOOL has been tested for insulating efficiency in various laboratories throughout the country. In a building insulated with BALSAM-WOOL, 20 to 35 per cent less radiation and boiler capacity is required. The coefficients given on the next page are taken or computed from information given in the A. S. H. & V. E. GUIDE 1930, and are recommended for use in computing the heat loss through sections insulated with BALSAM-WOOL. A complete file showing coefficients and the method of computing radiation requirements and fuel saving will be mailed on request.

*Taken from Journal of A. S. H. & V. E., Vol. 34, No. 7 (July, 1928), Page 536.
Insulation "C"—½ in. BALSAM-WOOL.

Heat Transmission Coefficients for Building Construction Insulated With BALSAM-WOOL

Section No.	TYPE OF CONSTRUCTION	Plastered Direct	Furred Wood Lath and Plaster	½″ B-W Single Furring*	½″ B-W Double Furring†	1″ B-W Single Furring*	1″ B-W Double Furring†
	Walls, Masonry:						
1	9″ Brick	0.332	0.209	0.141	0.116	0.112	0.096
2	13″ Brick	0.263	0.179	0.127	0.107	0.103	0.089
3	18″ Brick	0.208	0.152	0.113	0.097	0.093	0.082
4	6″ Hollow Tile, Stucco	0.299	0.196	0.135	0.112	0.108	0.093
5	8″ Hollow Tile, Stucco	0.273	0.184	0.129	0.108	0.104	0.090
6	12″ Hollow Tile, Stucco	0.193	0.144	0.108	0.093	0.090	0.079
7	4″ Brick Veneer, 4″ H.T.	0.277	0.186	0.130	0.109	0.105	0.091
8	4″ Brick Veneer, 6″ H.T.	0.246	0.171	0.122	0.104	0.100	0.087
9	4″ Brick Veneer, 8″ H.T.	0.228	0.162	0.118	0.100	0.097	0.084
10	4″ Brick Veneer, 12″ H.T.	0.169	0.130	0.100	0.087	0.084	0.075
11	12″ Stone	0.415	0.239	0.154	0.125	0.120	0.102
12	16″ Stone	0.356	0.218	0.145	0.119	0.114	0.098
13	20″ Stone	0.311	0.200	0.136	0.113	0.109	0.094
14	8″ Concrete, Stucco	0.437	0.246	0.157	0.127	0.121	0.103
15	10″ Concrete, Stucco	0.395	0.232	0.151	0.123	0.118	0.100
16	12″ Concrete, Stucco	0.361	0.220	0.146	0.120	0.115	0.098
17	16″ Concrete, Stucco	0.308	0.199	0.136	0.113	0.109	0.094
18	8″ Concrete Block	0.348	0.215	0.144	0.119	0.114	0.097
19	12″ Concrete Block	0.271	0.183	0.128	0.108	0.104	0.090
20	6″ Cinder Block, Stucco	0.328	0.207	0.140	0.116	0.111	0.095
21	8″ Cinder Block, Stucco	0.276	0.185	0.129	0.108	0.104	0.090
22	12″ Cinder Block, Stucco	0.210	0.153	0.113	0.097	0.093	0.082
23	4″ Cut Stone Veneer, 9″ Brick	0.300	0.196	0.134	0.112	0.108	0.093
24	4″ Cut Stone Veneer, 13″ Brick	0.234	0.165	0.119	0.101	0.098	0.085

Section No.	TYPE OF CONSTRUCTION	Not Insulated	½″ B-W†	1″ B-W†
	Walls, Frame			
25	Siding or Wood Shingles, Paper, Sheathing, Wood Lath and Plaster	0.227	0.122	0.099
26	Brick Veneer, Paper, Sheathing, Wood Lath and Plaster	0.216	0.118	0.097
27	Stucco, Paper, Sheathing, Wood Lath and Plaster	0.257	0.130	0.105
	Ceilings:			
28	Wood Lath and Plaster, No Floor Above	0.502	0.172	0.131
29	Wood Lath and Plaster, 1″ Pine Flooring Above	0.234	0.124	0.101
30	Wood Lath and Plaster, 1″ Pine, 13/16″ Oak or Maple Flooring Above	0.202	0.114	0.094
	Partitions:			
31	Studding, Wood Lath and Plaster One Side	0.502	0.172	0.131
32	Studding, Wood Lath and Plaster Both Sides	0.251	0.128	0.104
33	4″ Hollow Tile, Plaster One Side	0.31**	0.181*	0.135*
	Roofs:			
34	Built-up Roofing on 1″ Roof Boards, Wood Lath and Plaster Inside	0.258	0.130	0.105
35	Same as 34, with 2″ Roof Boards	0.213	0.117	0.097
36	Wood Shingles on Roof Boards, No Inside Finish	0.483	0.170	0.129
37	Same as 36, Wood Lath and Plaster Inside	0.246	0.127	0.103
38	Asphalt or Asbestos Shingles on Roof Boards, No Inside Finish	0.515	0.174	0.131
39	Same as 38, Wood Lath and Plaster Inside	0.259	0.130	0.105
40	Slate or Tile on Roof Boards, No Inside Finish	0.549	0.177	0.134
41	Same as 40, Wood Lath and Plaster Inside	0.262	0.131	0.105
	‡Roof and Ceiling Combined—Use Ceiling Area:			
42	Wood Shingles, Wood Lath and Plaster Ceiling, No Attic Floor	0.289	0.137	0.110
43	Same as 42, with Single Floor	0.174	0.105	0.088
44	Asphalt or Asbestos Shingles, Wood Lath and Plaster Ceiling, No Attic Floor	0.297	0.139	0.111
45	Same as 44, with Single Floor	0.177	0.106	0.089
46	Slate or Tile, Wood Lath and Plaster Ceiling, No Attic Floor	0.305	0.141	0.112
47	Same as 46, with Single Floor	0.180	0.107	0.089
	Floors:			
48	1″ Yellow Pine on Joists	0.440	0.164	0.126
49	13/16″ Maple or Oak Flooring on 1″ Yellow Pine on Joists	0.339	0.148	0.116
50	Same as 49 with ¾″ Matched Ceiling Boards Below	0.270	0.133	0.107

*Applied with one air space.
†Applied with two air spaces, except where noted.
**Plastered Direct.
‡Figured on basis of ⅓ pitch roof; sufficiently accurate for roofs of ¼ to ½ pitch.

Stewart InsoBoard Company

DEPENDABLE BUILDING INSULATION

Manufacturers of Dependable Building Insulation

St. Joseph, Missouri

PRODUCTS

InsoBoard and InsoLath, structural insulating board made of wheat straw fibre, for home, factory, hotel, apartment, and office buildings.

InsoBoard is made from the long, tough, sterilized, cellular fibres of straw, interlaced into flawless, sturdy panels $\frac{7}{16}$ in. thick, 48 in. wide, and any desired length. Used as sheathing or wall board, InsoBoard adds structural strength as well as insulation. It does not increase building costs, because in most places it replaces boxing, lath, and other materials. Labor costs are less, and InsoBoard makes the structure easier to heat and cuts fuel bills as much as one-third. It provides dependable insulation from heat and cold; retards fire and moisture, is a thorough sound deadener and insures warm floors free from dampness and draughts. No artificial binder is used to hold the fibres of InsoBoard together. Time and elements have no effect on it, submersion tests have shown any tendency to warp or buckle to be negligible, and it will not crack nor deteriorate. It handles easily; saws and nails same as any other material. It is proper width for standard spacing of studs, and cuts without waste.

InsoLath, same material as InsoBoard except that it is shiplapped and takes the place of ordinary wood lath as a plaster base. Possesses the same insulating and sound deadening qualities as InsoBoard, and provides a continuous plastering surface, so does away with lath marks, cracking of walls and ceiling, and stains through plaster. Plaster is applied direct to the surface of Insolath and holds better because the bond between Insolath and plaster is stronger than the key of plaster and lath.

Tests have proved the high insulating efficiency of InsoBoard. The Stewart InsoBoard Co. has subscribed to the two standard methods of testing the conductivity of insulating material and finding the exact loss of heat through that material. Both the "flat-plate test" and the "hot-box test" were used in tests of InsoBoard by G. F. Gebhardt, Mechanical Engineer of the Armour Institute of Technology, at Chicago, an internationally known and recognized authority on insulation values. The heat conductivity of InsoBoard in B.t.u. per 1 in. thick was found to be 7.78 per day by the "flat-plate" test and 6.0 by the "hot-box" test. The result of the tests by this impartial and disinterested authority proves that InsoBoard possesses a high degree of insulating efficiency and should be specified on jobs calling for maximum structural insulation.

Insolath *provides not only an ideal plaster base, but also insulation. It insures walls against cracks, crevices and stains*

General Offices
203 Wabash Avenue
Chicago, Ill.

THE THERM-O-PROOF INSULATION COMPANY

Manufacturing
Plant
Alton, Ill.

Therm-O-Proof as we apply it as a fill between studs, joists and rafters in a thickness of 3⅝ in. provides a higher heat resistance than materials installed in a ½ or 1 in. thickness.

THERM-O-PROOF

A production of lead slag, special process, removing all composites that would cause corrosion. Non-combustible, uniform, prepared in annealed or unannealed form.

GENERAL INFORMATION

Therm-O-Proof has been used quite extensively for a number of years, in its original form for the maintenance of high and low temperatures in the industrial field. It is not a new material but the application for residential use is new and made possible by our perfected application. There is no danger of Therm-O-Proof shrinking, bulging, warping, or cracking.

Being of mineral composition, Thermo-O-Proof will not deteriorate nor will it attract vermin, etc. Where used as a fill in between the studdings, it fireproofs the serious fire hazard in a home.

Therm-O-Proof is given a conductivity of 0.25 B.t.u. per hour per square foot per degree Fahrenheit. (Authority Professor J. C. Peebles, Armour Institute of Technology). Also see latest report of U. S. Bureau of Standards.

HOUSE INSULATION

Therm-O-Proof is blown pneumatically or hand packed, insuring a fill in between the studding at various densities which will completely prevent settling. Realizing the value of a correct installation, Therm-O-Proof is always installed in accordance with our specifications or any architectural specifications. Therm-O-Proof is a thick insulation and architects will find that recognized heating authorities will allow a reduction in radiation and boiler size which in some cases will go far towards paying the cost of the installation of Therm-O-Proof.

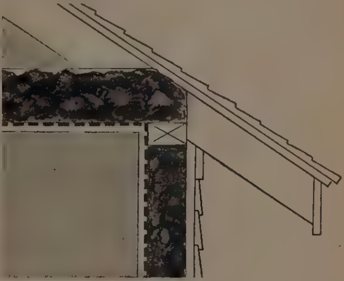
COSTS

The cost of Therm-O-Proof for a full, thick application, efficiently installed, is very reasonable. Quotations gladly furnished on request after a survey has been made by our competent, qualified, engineers.

SPECIFICATIONS—House Use

(a) Frame and Brick Veneer Construction

Therm-O-Proof shall be installed between all exterior walls, said side wall fill to be not less than 3⅝ in. thick. Therm-O-Proof shall be applied by authorized representatives of the Therm-O-Proof Insulation Company in accordance with these specifications, and any additional specifications by the architect.



(b) Masonry Construction

On all exterior walls Therm-O-Proof shall be hand packed between the furring strips before lathing; said strips shall be 1 by 2 in. and shall be blocked out with 1 by 2 in. blocks.

(c) Ceiling Insulation

Therm-O-Proof shall be installed as a 4 in. fill in between all top floor ceiling joists; said installation shall be made before plastering or after plaster is thoroughly dry, but in any case, before rough flooring is laid.

Further detailed information gladly furnished on request.

SOUND DEADENING

Therm-O-Proof shall be distributed over entire floor area, between floor strips and rough finish floors. Floor strips shall be 2 in. and nailed over felt pads, 2 to 3 in. off center with floor joists.

Therm-O-Proof is an ideal absorbent to use in connection with a sound deflector.

INDUSTRIAL USES

Therm-O-Proof, due to its texture and elasticity, is an ideal wool for maintenance of high and low temperatures. The annealing of the wool assures its fibres being tough and pliable and eliminates degradation. The oiled material is not greasy.

Therm-O-Proof is sold in forms suitable for all general insulation uses, such as mechanical vibrations, refrigeration, and acoustical correction.

For further information and complete set of architectural specifications, address inquiries to the home office, 203 North Wabash Avenue, Chicago, Ill.

Engineering advice furnished upon request.

Johns-Manville Corporation

Executive Offices
292 Madison Avenue, **New York, N. Y.**

SAN FRANCISCO CLEVELAND CHICAGO NEW YORK TORONTO

J-M 85% Magnesia

For High-Pressure and Intermediate-Pressure Steam Lines, high-pressure drip piping, including connections to all engines, turbines, pumps, auxiliaries, water columns, safety valves, superheaters and soot blowers, use Johns-Manville 85% Magnesia Insulation.

Johns-Manville 85% Magnesia

J-M 85% Magnesia is suitable for insulating all surfaces where temperatures up to 600 deg. fahr. are encountered.

Improved Asbestocel

For Low-Pressure, Exhaust Steam and Feed Water Piping use Johns-Manville Improved Asbestocel Sectional Insulation, 4 ply. Sectional Improved Asbestocel is furnished in thicknesses of 2, 3 and 4 ply, each ply being approximately ¼ in. in thickness. It is made in three foot sections with canvas jacket and brass-lacquered bands, to fit standard sizes of pipe.

For Steam Heating Supply and Return Mains, Risers and Radiator Branches use Johns-Manville Improved Asbestocel 4 ply. Concealed radiator branches should be insulated with 3 ply Improved Asbestocel. All other low-pressure and hot water pipes at pressures below 25 lb. or 267 deg. fahr., except heating returns, runouts and concealed radiator branches, should be insulated with Johns-Manville 4 ply Improved Asbestocel Insulation.

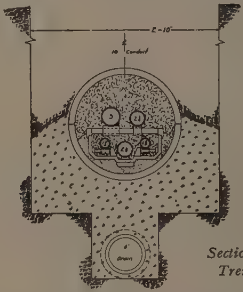
Johns-Manville Improved Asbestocel Insulation

Underground Insulation

For Steam, Hot Water and Fuel Oil Piping to be Installed Underground, use Johns-Manville System of Underground Insulation.

This system is complete. It provides insulation for the pipes, enclosure for the insulation, supports for the pipes and complete drainage by means of drain-tile and broken stone around the conduit.

For high efficiency (90% and more), permanency and economy use Johns-Manville System of Underground Insulation.



Section of Trench

Other Johns-Manville Insulations

Johns-Manville Superex Combination Insulation is for all superheated steam piping with temperatures of 600 deg. fahr. and higher.

Johns-Manville Asbesto-Sponge Felted is used on all high-pressure steam piping and high-pressure drip piping used in distribution of steam for manufacturing purposes.

Johns-Manville Anti-Sweat Insulation is specified for all cold-service water piping, including risers and concealed fixture connections or exposed soil or waste lines.

Johns-Manville Asbestocel Sheet Insulation is specified for warm-air ducts, flues, heater casings and fan housings in the ventilating system.

Block and cement insulation, to the same thickness as the adjacent pipe insulation, shall be used on all fittings, valves and flanges. Block insulation should be the same material as the adjacent pipe covering, and plastic material used shall be hard finish Asbestos Cement.

Keasbey & Mattison Company

"Makers of the Best in Asbestos"

Ambler, Pa.

BRANCHES

BALTIMORE, MD. CHICAGO, ILL. DETROIT, MICH. PHILADELPHIA, PA.
BOSTON, MASS. CINCINNATI, OHIO MINNEAPOLIS, MINN. PITTSBURGH, PA.
BUFFALO, N. Y., Care E. J. Eddy CLEVELAND, OHIO NEW YORK, N. Y. WASHINGTON, D. C.
CALIFORNIA DISTRIBUTORS: Farrington Engineering Co., LOS ANGELES
SOUTHERN DISTRIBUTORS
BIRMINGHAM, ALA., Dixie Asbestos Co. ST. LOUIS, MO., L. Mundet & Son, Inc.
KANSAS CITY, MO., Standard Asbestos Mfg. & Insulating Co.

PRODUCTS:

"Featherweight" 85 Per Cent Magnesia Pipe Covering and Blocks. High-Temperature Covering and Blocks. Ambler Asbestos Aircell Covering. Ambler Asbestos Cement. Asbestos Textiles of all kinds.

Company's Source of Asbestos

As Keasbey & Mattison Co. controls its source of crude asbestos, owning the Bell Asbestos Mines at Thetford Mines, P. Q., Canada, perhaps the world's most productive mines of high-grade Chrysotile Asbestos, this company is assured of a constant supply of long-fibred asbestos so necessary in making a thoroughly efficient insulation.

K & M 85 Per Cent Magnesia "Featherweight" Sectional Coverings and Blocks

Keasbey & Mattison Co. were the originators of 85 Per Cent Magnesia Covering, so called because it is composed of about 85 per cent basic carbonate of magnesia and 15 per cent of asbestos fibre. The magnesia is bound together with the long-fibred asbestos, giving it the necessary structural strength. K & M 85 Per Cent Magnesia "Featherweight" is very light in weight, fireproof and extremely durable. It will not injure piping and has a very high insulation value. Impartial expert engineering tests showing its superiority will gladly be sent upon request.

K & M 85 Per Cent Magnesia "Featherweight" Sectional Coverings are canvas-jacketed and 36 in. long per section. They are made in all standard and double standard thicknesses, 2-in. thickness, and 3-in. broken joint construction, and also in combination with Ambler High Temperature Insulation.

Ambler High Temperature Sectional Covering and Blocks

Recommended for temperatures in excess of 600 deg. fahr. These coverings are composed chiefly of asbestos fibre, bonded with inorganic binders found by experience to be best fitted for this class of insulation.

These coverings have a high insulating value and will withstand temperatures up to 1200 deg. fahr. Furnished in same moulded shapes and thicknesses as 85 Per Cent Magnesia Coverings and Blocks.

Ambler Asbestos Cement

Composed of asbestos fibre and inert materials having high insulating value, being superior to ordinary asbestos cements and surpassed only by 85 Per Cent Magnesia Cement.

Ambler Asbestos "Velvet" Cement

A fire-resisting and waterproof cement which gives a hard, smooth and beautiful finish to cement and block work, fittings and large or irregular steam surfaces. Furnished in 100-lb. bags.

Ambler Asbestos Paper, Coverings and Boards

Ambler Asbestos Aircell Coverings—These are composed of various thicknesses of asbestos corrugated paper, each ply being about ¼ in. thick. These thicknesses united form a covering which is light, fireproof and very satisfactory for low domestic heating and piping insulation. Made in 2, 3 and 4 plies.

Telephone
Main 9200

Established 1910

The Ric-wiL Company

UNDERGROUND CONDUIT SYSTEMS FOR HEATING PIPES

Union Trust Building, CLEVELAND, OHIO

NEW YORK BALTIMORE ATLANTA CHICAGO

AGENTS IN PRINCIPAL CITIES—REFER TO LOCAL TELEPHONE DIRECTORY

Products—RIC-WIL Conduit, which includes Base Drain, Pipe Supports, Insulation and other accessories, for underground steam, hot water and fuel oil pipes. Cast Iron Conduit for extra heavy duty.

Ric-wiL Conduit—Vitrified tile, bell and spigot type, which splits on the job for easy installing. Special Loc-liP Side Joints seal top and bottom halves together again after pipes and insulation are installed. A strong, watertight joint. Sections 2 ft. long. Sizes I. D. 4 to 24 in.

Ric-wiL Base Drain—Vitrified tile. Designed to be a base drain foundation for supporting and lining up conduit and drain for carrying away moisture. Slotted sections interlock with conduit bells to form a strong construction.

Ric-wiL Pipe Supports—Planned to carry one to five or more pipes and ordinarily spaced 12 ft. apart. Made of rust-proof cast iron. Interlocked with base drain, imposing no load on conduit itself.

Ric-wiL Conduit Systems for All Uses—*Type F* System for steam heating and power plants. Unlined RIC-WIL Conduit with filler packed around pipes. Dry-paC Waterproof Filler if desired.

Type SPC system for steam heating and power pipes and super-heated steam. Insulation standard pipe covering.

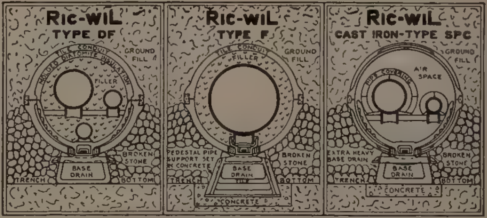
Type DA system for hot water, fuel oil, and condensation returns. Sil-O-Cel Insulation moulded to inside of tile and keyed in. Pipes insulated from outside earth but not from each other.

Type DF system for steam heating and power pipes. Type DA with addition of RIC-WIL Conduit Filler packed around pipes. Dry-paC Waterproof Filler if desired.

Cast Iron Ric-wiL Conduit—For extra heavy duty under railroads or other places where conduit is subject to abnormal strain. Similar in design to tile RIC-WIL. Heavy duty base drain.

Dry-paC Waterproof Filler—Permanently impervious to water, repells moisture. Unusually high efficiency and great natural strength. Will not slump down away from pipes. Is non-corrosive.

Engineering Service—Help in planning and supervision. Catalogs and special information on request.



ADVANTAGES OF THE RIC-WIL SYSTEM

MECHANICAL

WATER-TIGHT: JOINTS COMPLETELY SEALED AND CEMENT LOCKED IN

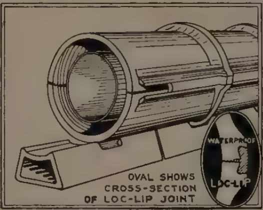
STRENGTH AMPLE FOR USUAL CONDITIONS 40% STRONGER THAN ANY OTHER TILE SYSTEM.

INTERLOCKING CONSTRUCTION: CONDUIT AND BASE DRAIN STAGGER JOINTS, PIPE SUPPORTS LOCKED IN PLACE. TOP AND BOTTOM OF CONDUIT LOCKED TOGETHER AND CEMENT LOCKED IN.

FOOL PROOF: TOP AND BOTTOM OF CONDUIT ALIKE. CAN NOT INSTALL UP SIDE DOWN.

BASE DRAIN: FOUNDATION AND CRADLE FOR CONDUIT TO REST ON.

PERMANENCY: MATERIALS ALL OF PERMANENT CHARACTER.



PRACTICAL

SPEED OF INSTALLATION: IMPORTANT FOR STREET WORK.

COMPLETE SYSTEM. RIC-WIL SYSTEMS ARE FURNISHED COMPLETE IN ALL DETAILS.

MINIMUM PUBLIC LIABILITY: LESS CONSTRUCTION IN STREETS.

TRENCH WIDTH: RIC-WIL REQUIRES LEAST TRENCH WIDTH SAVES ON PAVING COST.

CEMENTING JOINTS: EXTRA EASY. CEMENT A WHOLE RUN AT ONE TIME.

INSPECTION: LOC-LIP JOINT VISIBLE FROM TOP OF TRENCH.

DRY INSULATION: DESIGN KEEPS INSULATION DRY AT ALL TIMES - EFFICIENCY.

COST: LABOR COST OF INSTALLATION IS LOW, AND TOTAL COST IN LINE.

Ric-wiL Type F with Dry-paC Waterproof Insulation packed around pipes. Fully closed construction

Builders Iron Foundry

9 Codding Street Providence, R. I.

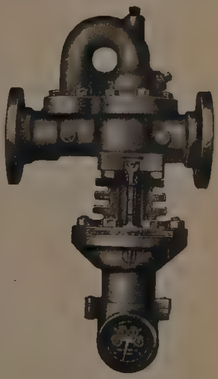
Branch Offices and Representatives

New York, N. Y.....25 Church Street
Pittsburgh, Pa.....1503 Oliver Building
Philadelphia, Pa.....617 Harrison Building
Chicago, Ill.....466 Peoples Gas Building
San Francisco, Calif.....Percy Keatinge, 85 Second Street
Los Angeles, Calif.....Percy Keatinge, c/o Pacific Mfg. Co., 530 West 6th Street
Dallas, Texas.....Morey & Morey, 417 Praetorian Building
Charlotte, N. C.....Grinnell Co., Inc., P. O. Box 336
Toronto, Ont., Can.....Allen General Supplies, Ltd., 15 Toronto Street
Atlanta, Ga.....Wm. F. Wilcox, Fourth National Bank Building
Seattle, Wash.....California Filter Co., 1005 Securities Building
Kansas City, Mo.....Terry, Cowan & Smith, Inc., 1005 Davidson Building
Vancouver, B. C., Can.....Chas. A. Moorehead, c/o R. C. Cooper & Co., Ltd., 615 Pender Street, West
Buenos Aires, Argentina, S. A.....Major Geo. C. Robertson, 760 Avenida de Mayo

Builders of the Venturi Meter, Diaphragm Meter, Shunt Steam Meter, Etc.

SHUNT STEAM METER

The Shunt Steam Meter fills the need for a low priced, practical steam meter which is easily installed and accurate over a wide range. It is used to advantage in measuring steam sold or in checking the distribution of steam (also air or gas) to various buildings, departments, machines or processes. Illustration shows the complete Meter. An orifice in the main line of flow deflects a portion of the steam through nozzles and against the turbine located in the shunt circuit out of the main line of flow. The turbine shaft extends through a housing into a condensation chamber below the main line. A damping fan attached to this shaft operates under water, keeping the speed low and eliminating bearing trouble. Magnetic drive between this chamber and the counter mechanism protects the latter from moisture. The meter is installed as a unit in 2, 3 and 4-in. lines. For larger size mains a small meter is installed in a by-pass line around an orifice in the main line.



Shunt Steam Meter, Type KS.

	Steam Pressure Lbs. per Sq. In. Gauge	Approximate Measuring Range	Rated Capacity of Saturated Steam Lbs. per Hour		
			2″ Meter	3″ Meter	4″ Meter
Low Pressure Meters	0	10–1	610	1410	2530
	5	10–1	810	1880	3350
	10	10–1	1000	2340	4170
	15	10–1	1200	2750	4750
	20	10–1	1380	2950	5150
	30	11–1	1650	3400	5850
	40	12–1	1800	3750	6450
	50	13–1	2000	4050	7000
Standard Meters	50	10–1	2650	6000	10600
	75	10–1	3650	8250	14600
	100	11–1	4150	9500	16600
	125	12–1	4600	10500	18300
	150	13–1	5000	11400	20000
	175	14–1	5350	12300	21400
	200	15–1	5700	13000	22700
Extra Heavy Meters	225	15–1	6000	13700	24000
	250	15–1	6300	14400	25200
	275	15–1	6600	15200	26500
	300	15–1	6900	15700	27500

Table shows rated capacities only. Minimum Capacities equal one-tenth tabulated quantities. Where Approximate Measuring Range exceeds 10-1 the Meter has that overload capacity.
Bulletin 234 gives complete information.

The Higgin Manufacturing Co.

Newport, Ky.

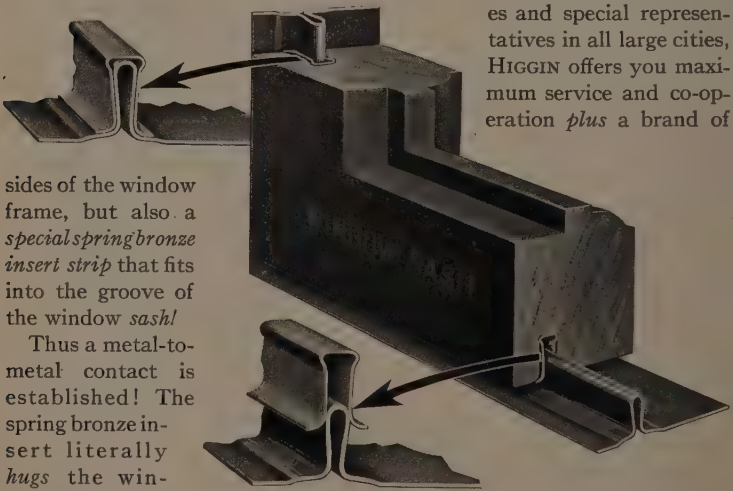
Manufacturers of Metal Weather Stripping for Windows and Doors

Representatives in Principal Cities

HIGGIN
ALL METAL
Weatherstrips

Higgin all-metal weatherstrips are distinctly different from those of other manufacturers. HIGGIN not only has the usual metal strip which is fitted to the four sides of the window frame, but also a *special spring bronze insert strip* that fits into the groove of the window *sash!*

Thus a metal-to-metal contact is established! The spring bronze insert literally *hugs* the window, and provides absolute protection against drafts, dust, dirt, and irritating rattles. Even though the window sash shrinks (as so often happens) the metal-to-metal contact remains totally uneffected—cold air positively cannot gain entrance. The efficiency of the heating system is increased 25 per cent and upwards!



THE HIGGIN ORGANIZATION, backed by 35 years of constant progress, is fully prepared to weatherstrips all types of openings—double hung windows, casements and doors. With branches and special representatives in all large cities, HIGGIN offers you maximum service and co-operation *plus* a brand of weatherstripping without equal.

If your files do not already contain full information on HIGGIN weatherstrips, a word from you will bring same.

Space here does not allow the reproduction of test data on the Higgin Insert Equipment prepared at the University of Wisconsin. A folder however is available covering this test and copies will be sent on request.

The Higgin Manufacturing Co.

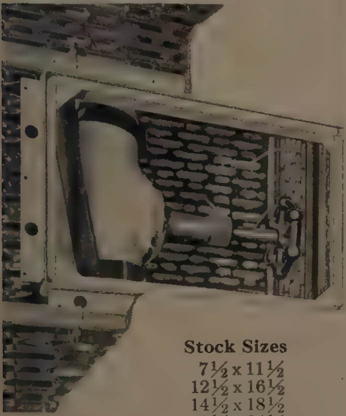
Newport, Ky.

Manufacturers of Metal Access Panels for Heating and Plumbing Systems

Representatives in Principal Cities

HIGGIN
ALL METAL
Access Panel

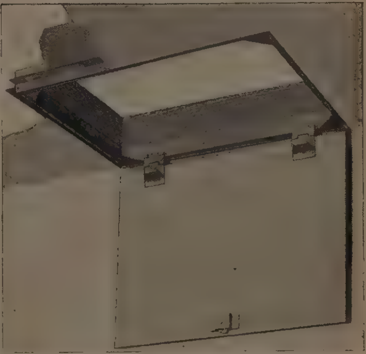
Illustration below shows panel used for access to concealed valve. Plaster is shown broken, to expose metal lath and method of fastening. Lid is shown removed from frame. (Right) Hinged type panel in ceiling. Either hinged or removable lid may be furnished.



Stock Sizes

7½ x 11½
12½ x 16½
14½ x 18½
18½ x 24½
18½ x 30½

Measurements are in rabbet.



The Higgin All Metal Access Panel was designed to meet a pressing need for an inconspicuous flush panel for access to critical places in Heating, Plumbing and Refrigerating systems. The panel is entirely of metal.

They are made as a unit. No assembling at the job.

Installation is simple and no special framing or grounds are necessary. The panel is composed of a frame and lid. The frame is in one piece with a continuous angle on the inside, forming a rabbet for the lid. Perforated angles are spotwelded to outside of frame for fastening and plaster key. On the smaller panels friction catches hold the lid in place. For the larger sizes, retaining clips and special cam fasteners are used. Concealed hinges may be provided if desired in place of the retaining clips. Panels may be installed in walls faced with plaster, tile or marble. They can be painted, decorated or papered over.

Higgin All Metal Access Panels are ideal for use in Hospitals, Apartment Houses, Hotels, Residences, Offices and other Buildings.

WRITE FOR COMPLETE DESCRIPTIVE LITERATURE

GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y.
Sales Offices in Principal Cities

Motor and Control
For Heating, Ventilating and Air Conditioning Systems
Quiet Operating Motors

The Need for Quiet Operating Motors

This company has, for some time, been aware of the fact that induction motors of the general purpose line are not quiet enough for use in office buildings, schools, etc., where quiet operation is of great importance, although these motors are not objectionable for other classes of service. This fact was pointed out at various times so as to guard against the application of standard motors in such locations, but this warning has been generally disregarded, and although a great number of standard motors have been applied successfully in such buildings, there have also been a number of complaints on noise from customers who have used standard motors.

Acoustics of the Structure, Location and Mounting

The problem of reducing noise in buildings should not be left entirely to the motor manufacturer, and although it has been found that many architects fully appreciate the noise problem and their specifications cover very fully the precautions which must be taken in mounting the equipment, there are architects who are apparently overlooking this problem entirely and make no provision for covering this point at all.

Concrete, which is usually used in conjunction with steel in modern building construction, is a nearly homogeneous substance of high density, liberal elasticity and is an excellent conductor of sound waves, while concrete arches are potential sound amplifiers. The importance of correctly designing foundations is best illustrated by a case which has come to our attention where, in the motor room, there was no objectionable noise, yet on certain lower floors, the noise was very objectionable, the noise being transmitted by the steel work and amplified by the sounding-board effect of the walls, and sometimes further intensified by localized resonance.

MTB Wound Rotar Quiet Operating Induction Motor

One of the best methods for preventing the transmission of sound is to use a laminated structure across the direction of the sound wave, the lamination varying in density so as to cause multiple reflection.

Materials which can be used in constructing proper foundations are cork pads (2 to 3 in. thick), felt pads, sheet lead, wood and sand used in combination with reinforced concrete or steel.

It has been found that when cork is used, the foundation should be designed so that the pressure on the cork will be 30 lb. per sq. in.; either more or less does not seem to produce as satisfactory results. A block of cork 2 in. thick should not compress more than 0.272 in. under a pressure of 10,000 lb. per sq. ft. of surface area. The installation should be made so as to eliminate any metal-to-metal contact between motor and building.

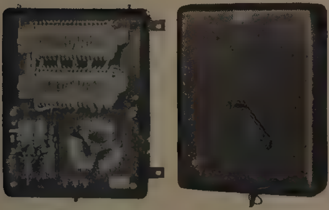
The use of short center belt, texrope drive or worm gear drive should be recommended wherever possible as this enables higher speed motors to be used—900 and 1200 r. p. m. motors are recommended rather than the lower speed motors such as 450 r. p. m., giving better efficiency and far better power factor. In addition, the connecting of motors in this way allows proper insulating foundations to be used under the motor without affecting the line-up of the drive. Where the motor is direct connected to the drive, especially low-speed fans, the most satisfactory

This Company will gladly assist in the solution of any electrical problem in relation to heating and ventilation

Motors and Control

For Heating, Ventilating and Air Conditioning Systems

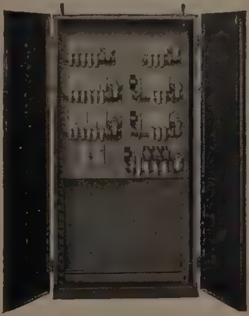
Alternating Current Control



CR7765, 1-5 Hp. Controller

method of mounting is to have both motor and fan on a common base, the whole base being mounted on proper insulating supports. Where the fan and motor are not on the same base, it is difficult to use any sound absorbing insulation under the motor without causing difficulty in keeping the equipment properly lined up.

The location of the motor in the building with reference to the acoustics of the surrounding structure is a very important point, and while in one location a perfectly standard motor may be acceptable, the same motor may be entirely unsuitable in another location.



CR7761-F1, 20-50 Hp. Controller

Switches

Method of Operation	Type	Horsepower Range	Overload Protection	Remarks
Manual	CR1924	¼–50	Fuse	Safety Type.
Manual	CR1038	¼–5	Thermal Cut-outs	Tumbler Switch.
Push Button	CR7006	1 –50	Temperature Relay	Contactor.
Push Button	CR7006F1	1 –5	Fuse and Temperature Relay	Combined Magnetic Switch and Disconnection.

Starters

Method of Operation	Type	Horsepower Range	Overload Protection	Remarks
Manual	CR1034	5 –50	Temperature Relay	Compensator Type.
Manual	CR1042	5 –15	Temperature Relay	Resistance Type.
Push Button	CR7056	2 –50	Temperature Relay	Resistance Type.
Push Button	CR7051	5 –50	Temperature Relay	Compensator Type.
Push Button	CR7773	1 –5	Time Limit	Combined Magnetic Starter and Circuit Breaker.

Speed Regulators

Method of Operation	Type	Horsepower Range	Overload Protection	Remarks
Manual	CR1264	1 –15		Requires Separate Switch.
Manual	CR7764C1	7½–50	Temperature Relay	Combined Regulator and Switch.
Manual	CR7764Y1	5 –50	Time Limit	Combined Regulator and Circuit Breaker.
Push Button	CR7765	1 –5	Temperature Relay	Preset Speed Type.
Push Button	CR7761	5 –50	Temperature Relay	Remote Speed Indicating.

The General Electric Co. manufactures a complete line of control devices for starting and controlling motors driving ventilating fans. The table above gives briefly the line of controllers for use with alternating current motors. All controllers are of the enclosed type externally operated. Speed regulators are designed to give 50 per cent speed reduction on fan load and arranged to maintain equalized current in all phases of the rotor which is necessary to maintain quiet operating motors.

Details may be obtained at the nearest sales office.

This Company will gladly assist in the solution of any electrical problem in relation to heating and ventilation

Westinghouse Electric & Manufacturing Co.

East Pittsburgh, Pa.

Sales Offices and Service Shops in All Principal Cities

There's a Westinghouse motor with matched control to suit the requirements of every heating and ventilating system.

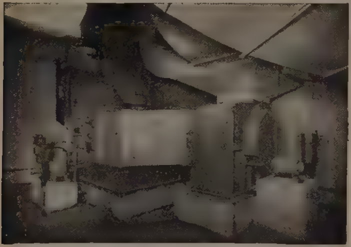


Fig. 1—At the Fox Theatre, San Francisco, California. At the left, a Western Blower Company air conditioning system is shown. A Westinghouse small, constant-speed motor with a Line starter drives the centrifugal motor pump for this system.

The blower fan at the right is belt-driven, at reduced speed, by a Westinghouse type CS constant-speed, Line start squirrel cage motor.

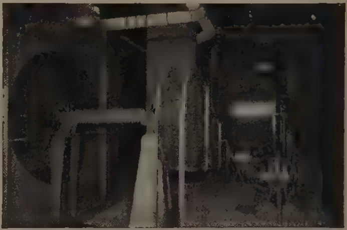


Fig. 2—In the Rhodes Department Store, Seattle, Wash. The large Western Blower Company fans are belt-driven by Westinghouse type SK variable-speed, direct current motors. This type of drive is used in direct-current applications to meet the requirements of a high starting torque and variable-speed duty.

Fig. 3—In the Fox Theatre, San Francisco, California are three Westinghouse type CS, constant-speed Line start motors driving blowers; one is directly connected, while the other two drive by belt at reduced speed. The control for each consists of a Line starter and push button.

Fig. 4—In the Holland Tunnel, New York River Building. A Sturtevant Blower Fan connected by a Link-Belt chain-drive to a Westinghouse type CW, 200 hp., adjustable speed, wound rotor induction motor. This type of motor is used in alternating current applications where high starting torque and variable rates of air circulation are required

Fig. 5—In the Stevens Hotel, Chicago. Two large blower fans, each directly connected to a Westinghouse type SK, low-speed, direct-current, variable-speed motor. This application could be advantageously controlled by the remote system shown in the illustration of Figure 6.

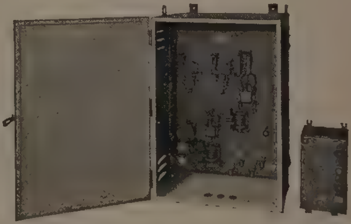


Fig. 6—The air circulation may be varied or the fan motors may be stopped from a point remote from the fan room by pressing the proper button of this Westinghouse remote control equipment. This consists of controller and visual control station.

Westinghouse engineers offer you their services in the planning of every phase of building electrification.

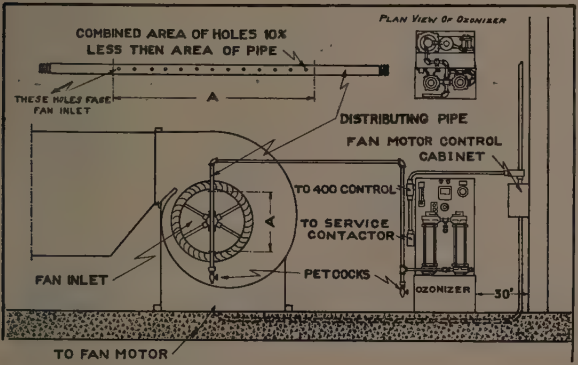
United States Ozone Company

Engineers — Manufacturers — Chemists

Pacific Coast
Montgomery Brothers
61 Fremont Street
San Francisco

500 North Dearborn Street
Chicago, U.S.A.

Canada
Darling Brothers, Ltd.
140 Prince Street
Montreal



Capacity of Electric Service 2.5 K. V. A. for fan capacities 25,000 to 120,000 c.f.m. Normal operating load for producing ozone 0.5 kw per hour.

Space Requirements

For general ventilation the space requirement for fan capacities of 25,000 to 120,000 c.f.m. is 28 x 36 x 62 in. elevation. See plan view and typical layout above. Aisle space of 3 ft. should be allowed at the front and one side. Back may be placed against wall. For larger fan capacities and special multiple unit assembly for handling a number of fans, see our Bulletin No. 50 or communicate with our nearest office.

Engineering Detail

See chapter on ozone in text section.

For Cold Storage Plants

we provide United States Controlled Ozone Apparatus for maintaining the air pure, and fresh, oxidizing odors and inhibiting mold growth, etc.

For Water Purification

we provide United States Ozone and other Apparatus for treating potable waters, destroying all pathogenic bacteria, odors and tastes, particularly the odor and taste of chlorine. Special attention is given to SWIMMING POOLS.

Stockham Pipe & Fittings Co.

Birmingham, Alabama

Warehouses: BOSTON NEW YORK CHICAGO HOUSTON LOS ANGELES

PIPE FITTINGS

Cast Iron	Malleable	Electric Cast Steel
Screwed ⁓ Flanged	*Standard ⁓ Extra Heavy*	*Flanged*
Drainage ⁓ Sprinkler	*Hydraulic ⁓ Oil Country*	*Screwed*

There are over 7,500 patterns in the complete Stockham line. Every pipe fitting requirement for gas, water, steam, oil or air, is met by Stockham. All Stockham Fittings are accurately threaded and flanged. They are always in perfect alignment. Made according to the American Standard, therefore interchangeable on any standard pipe lines. Free from sand holes, blow holes or sponginess; strong, far in excess of probable strain. Tough, uniformly grained metal, easily drilled or otherwise machined; smooth inside and out; attractively finished, and when galvanized, coated with a double lustrous coat of finest quality spelter.

CAST IRON FITTINGS

Screwed Flanged
Drainage Sprinkler

Made according to the American Standard. Accuracy in pattern, accuracy in proportioning materials, accuracy in melting, accuracy in molding, accuracy in finishing, accuracy in inspecting and testing.

Stockham Sprinkler Fittings are made in accordance with the requirements of the National Fire Protection Association and are known as American Standard Sprinkler Fittings, being made to the specifications of the American Standards Association. They also have the approval of the Associated Factory Mutual Fire Insurance Co's. and the Underwriters Laboratories.

MALLEABLES

Standard, Extra Heavy, Hydraulic and Oil Country

All Stockham Malleables are made according to the quality standard which distinguishes all Stockham fittings. Annealing under definite temperature control which gives ductility, uniform structure and high strength with great resistance to shock and strain.

CAST STEEL

Flanged Fittings and Flanges

Conform to the American Standard. Walls are designed thicker than American Standard Requirements. Regular in outline; conformity to patterns; ample fillets well rounded. Meet specifications of the *American Society for Testing Materials.*

Every fitting hydrostatically tested before shipment. Exceptionally smooth inner and outer surfaces; accurate facings and fine appearance. Made for pressures of 150, 300, 400, 600, 900 and 1350 lb. and for temperatures according to the American Standard.

CAST STEEL

Screwed Fittings

Every needed design and size. Same quality standard as Flanged Fittings and Flanges. Accurate threads, accurate alignment, smooth inner surfaces. Strength far in excess of probably strain.

Descriptive Catalogs on request.

STOCKHAM FITTINGS

Are sold by leading wholesalers

HEATING AND VENTILATING

Formerly The Heating and Ventilating Magazine

Founded 1904

521 Fifth Avenue **New York City**

LEADERSHIP—

Conclusively Proven Through Increasing Editorial and Advertising Volume Reflecting the Growth of the Industry—

Heating
Ventilating
Air Conditioning
District Heating
including
Automatic Heating
with
coal—oil—gas—electricity

Heating and Ventilating has just passed its quarter-century mark in devoting itself exclusively to serving the heating and ventilating industry. Always pledging itself to its readers above all other obligations, always accepting only worthy advertising, always ready to sponsor newer, more efficient methods.

The industry and its engineers and contractors in recognition of this cooperation and service, has accepted **Heating and Ventilating** as an authority in the field. With the cooperation of those progressive engineers and contractors who have given so generously of their knowledge, **Heating and Ventilating** has been largely instrumental in bringing about a better understanding of the many difficult problems which have arisen from the vast changes and improvements in heating, ventilating and air conditioning equipment as occurring over a period of twenty-five years.

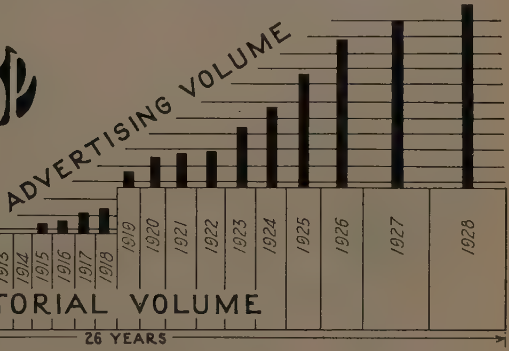
Heating and Ventilating offers the manufacturer and distributor of heating, ventilating and air conditioning equipment a direct first-read medium of sales contact to the men who specify, buy and install this equipment.

Wherever an office building, apartment house, hotel, school, home, church, hospital or industrial building is planned, there will be found the heating and ventilating engineer in consultation with the architect, the heating contractor and the builder. These are the men who read **Heating and Ventilating.**

Sample copies, rate cards and market information sent upon request.

MEMBER
AUDIT
BUREAU
OF
CIRCULATIONS

ABP



American Society of Heating and Ventilating Engineers

29 West 39th Street, **New York**

THE CODE OF MINIMUM REQUIREMENTS

for the

HEATING AND VENTILATION OF BUILDINGS

(Edition of 1929)

$5.00 per Copy

The Code has been recently published by the American Society *of* Heating *and* Ventilating Engineers, *New York, in fourteen sections, bound attractively in a loose leaf holder.*

Each section was prepared by a Sub-Committee and the following subjects are covered:

Section I—Minimum Ventilation Requirements for Public Buildings.

Section II—Minimum Requirements for Estimating the Heat Required for Warm Buildings.

Section III—Minimum Requirements for the Determination of the Amount of Direct Steam and Hot Water Radiating Surface to be installed in Steam and Hot Water Heating Systems.

Section IV—Minimum Requirements for the Determination of the Amount of Indirect Steam or Hot Water Heating Surface to be Installed in Indirect Gravity and Fan Circulation Heating and Ventilating Systems.

Section V—Minimum Capacity and Installation Requirements for Low Pressure Steam and Hot Water Heating Boilers.

Section VI—Minimum Requirements for the Design and Installation of Warm Air Furnace Heating Plants.

Section VII—Minimum Requirements for the Design and Installation of Chimneys or Stacks for Steam Boilers, Hot Water Boilers and Warm Air Furnaces.

Section VIII—Minimum Requirements for Pipe Sizes for Use with Low Pressure Steam, Vapor and Vacuum Heating Systems.

Section IX—Minimum Requirements for Pipe Sizes for Use with Gravity and Forced Hot Water Heating Systems.

Section X—Minimum Requirements for the Design and Installation of Air Ducts, Inlets and Outlets, in Conjunction with Fan Air Circulation, and the Installation of Ventilating Fans for Use with Steam and Hot Water Heating and Ventilating Systems.

Section XI—Minimum Requirements for the installation of Air Washers and Filters.

Section XII—Pumps for Heating and Ventilating Equipment.

Appendix I—Formulae for Physical Units, Air and Vapor Mixtures, Etc.

Appendix II—Standard Symbols for Heating and Ventilating Drawings.

The Code consists of 158 pages and is fitted into a loose leaf binder with black flexible cover. It is printed on India Tint stock, 6 x 9 inches in size.

The Code of Minimum Requirements was developed as a result of numerous requests made to the Society by engineers, architects, municipalities, engineering and trade organizations and its purpose is to standardize as far as practical the installation of heating and ventilating equipment.

The Code represents minimum requirements as called for by good engineering practice and is so written that it may be incorporated as a part of a Municipal Building Code, if found desirable.

American Steam Pump Company

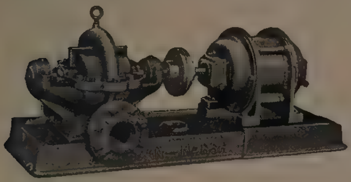
Plant and General Offices: **Battle Creek, Michigan**

NEW YORK: 17 Battery Place
CHICAGO: 926 Monadnock Bldg.

American-Marsh Pumps

Sales and Service Agencies
Throughout the World

Manufacturers of High Grade Centrifugal Steam and Power Driven Pumps of all Approved Types to Meet Every Industrial and Public Building Requirement

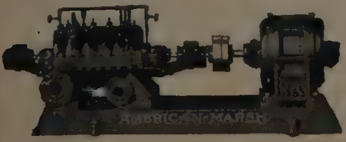


American-Marsh Centrifugal Pumps—New Type HL Single Stage Centrifugal Pumps, shown above cost less to run, due to higher efficiencies and ball bearings (standard equipment). Furnished with bronze seal rings, bronze impellers hydraulically balanced, and split cases. Ideal for hot or cold water circulating, low pressure boiler feed, air washer service, etc. Designed with non-overloading characteristic and many other important features. Bulletin 61.

Also other centrifugal pumps in all approved types, both single and multistage, split or solid case. Adaptable to any liquid handling job with sizes to meet all needs. Bulletins 25, 38 and 53.

American-Marsh Condensation Pumps and Receivers—Both steam and centrifugal motor driven types in sizes to meet all requirements. Furnished complete with control equipment. Bulletins 27 and 32.

American-Marsh Steam Pumps—Both simplex and duplex types in sizes to cover any liquid handling requirement, such as boiler feed, tank filling, etc. Bronze fitted throughout. 225,000 units in service. Bulletins 26 and 28.



Multistage Centrifugal Pump

American-Marsh Sump Pumps:—Designed for automatic operation, elevating sewage and drainage to sewer levels, for cellar drains, etc. Current used only when pump runs; pump always submerged ready to start. Sizes to handle all jobs. Simple design for faithful service without attention. Also built as duplex units, similar in construction except that two complete pumps are mounted on one cover plate. Bulletin 41.

Sump Pump

Steam Vacuum Pump

American-Marsh Vacuum Pumps:—Standard equipment includes bronze fittings throughout. Designed for all vacuum heating needs with sizes to handle up to 200,000 sq. ft. radiation. Motor driven if desired. Bulletin 24.

Guarantees and Engineering Service:—Every pump is rigidly tested and guaranteed to meet conditions specified. It is further guaranteed against any defects in material and workmanship. Write for the co-operation of our engineers. Our forty years' experience is at your disposal.

Buffalo Steam Pump Co.

"Builders of Better Pumps Since 1887"

450 Broadway, **Buffalo, N. Y.**

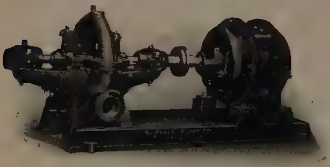
Complete Line manufactured in Canada by
Canadian Blower & Forge Co., Ltd., Kitchen, Ont.

Branch Offices

Ammarillo, Texas	Ammarillo Bldg.
Boston, Mass.	10 Milk Street
Chicago, Ill.	562 W. Washington Blvd.
Cleveland, Ohio	368 Rockefeller Bldg.
Cincinnati, Ohio	604 Mercantile Library Bldg.
Dallas, Texas	601 Construction Bldg.
Denver, Colo.	1621—17th Street
Detroit, Mich.	2051 W. Lafayette Blvd.
Indianapolis, Ind.	State Life Bldg.
Los Angeles, Calif.	610 Pershing Square Bldg.
Minneapolis, Minn.	459 N.W. National Life Bldg.
New York, N. Y.	39-41 Cortlandt Street
Philadelphia, Pa.	1302 Land Title Bldg.
Pittsburgh, Pa.	927 Union Trust Bldg.
Portland, Ore.	355 Everett Street
San Francisco, Calif.	365 Tenth Street
St. Louis, Mo.	906 Chemical Bldg.
Seattle, Wash.	303 Alaska Bldg.
Washington, D. C.	418 Washington Loan Trust Bldg.

PRODUCTS

Centrifugal Pumps For All Purposes—Single and Double Suction, Single and Multistage, Horizontal and Vertical. Steam Pumps—Duplex and Simplex, Inside Packed and Outside Packed. Vacuum Pumps and Condensers.



Class "S" Double Suction Centrifugal Pump

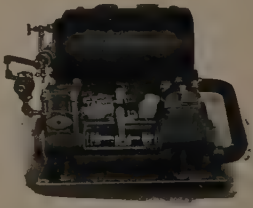
Horizontally divided casing. Extensively used with air washers, and for circulating systems and booster service.

Automatic Sump Pump

Self contained. Ball bearing thrust.

Centrifugal Condensation Return Pump and Receiver

Also built vertical with receiver pit. Especially adapted for low pressure boilers. Automatic in operation.



Duplex Steam Pump and Receiver

Entirely automatic. Can be furnished for high or low boiler pressure.

Complete Descriptive Catalogs Furnished Upon Request

Decatur Pump Company

Decatur, Ill.

BURKS
SUPER-TURBINE
PUMPS
Only one moving part

A SATISFACTORY CONDENSATION RETURN UNIT TO INSTALL

Series 4700
Condensation Return Unit

The Burks Condensation Return Unit is made in two styles—Series 4700 and Series 41100. The two styles are capable of handling the condensate of heating systems covering a range of from 2,000 to 12,000 sq. ft. of steam radiation. Condensation computed on basis of .25 lb. of water per hour per square foot of radiation. Gravity return to receiver tank. Low pressure on radiation.

The entire unit is sturdy and built for service. Due to extremely compact construction, the Series 4700 Unit can be installed to occupy a floor space of only 24 in. sq., and the larger Series 41100 Unit occupies a floor space of only 40 in. sq.

The pump capacities range from 180 to 1,080 g.p.h. The condensate range is from 60 to 360 g.p.h. These Units handle hot water in a highly satisfactory manner.

Construction Features

Only one moving part—no metal-to-metal contact.

Self-priming—Pumps air alone to high pressure.

Pumps water alone to high pressure.

Pumps air and water mixed to high pressure.

Operating working pressure 100 lb., using Series 41100.

Stainless steel, acid-proof, non-corroding shaft—carried in oversize ball bearings.

Tank of copper-bearing steel; $\frac{3}{16}$-in. shell; $\frac{1}{4}$-in. top and bottom, welded construction.

Impeller and Raceway of Cast Bronze

Balanced hydraulic load—insuring minimum torque.

Will Not Steam Bind

When ordering Burks Condensation Units, always furnish the following information:

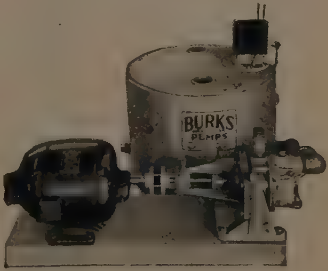
Total number of square feet of radiation to be served.

Operating pressure (pop setting) of heating boiler used.

Kind of current available.

Direct Current, show voltage.

If Alternating Current, show cycles, voltage and phase (1, 2 or 3 phase).



Series 41100
Condensation Return Unit

CHICAGO PUMP COMPANY

SEWAGE-CONDENSATION-CIRCULATING
BILGE-FIRE-HOUSE-VACUUM

2330 Wolfram Street
Chicago, Ill.

PRODUCTS—Electric Centrifugal Pumps, Sewage, Bilge, Fire, House, Circulating, Pneumatic and Tankless Water Systems, Condensation, Vacuum, Cellar Drainers

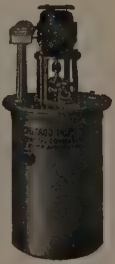
List of Representatives

ARIZONA,
Phoenix, J. W. Ladlow
ALABAMA,
Birmingham, C. P. Leibold
CALIFORNIA,
Los Angeles,
Smith Booth Usher Co.
San Francisco,
Jenison Machinery Co.
COLORADO,
Pueblo, M. R. Schwer & Co.
Denver, A. Wallace & Co.
CONNECTICUT,
Hartford,
Boiler Equipment Co.
DISTRICT OF COLUMBIA,
Washington, W. L. Ticer
FLORIDA,
Coconut Grove,
R. H. Magruder Co.
Jacksonville, G. E. Osgood
Tampa, H. G. Carter
GEORGIA,
Atlanta, J. R. Whitman
Savannah, Bergen & Peck
ILLINOIS,
Peoria, C. E. Kallister Co.
INDIANA,
Fort Wayne,
Domestic Sales Co.
Indianapolis,
W. P. Whittington Co.
IOWA,
Des Moines, E. B. Carr
Des Moines,
H. F. Willis, 521 Securities Bldg.
Sioux City, Wigman Co.
Davenport,
A. R. Boudinot
KANSAS,
Wichita, J. M. O'Connor
KENTUCKY,
Louisville, Wallace Hoeing,
LOUISIANA,
New Orleans, H. J. Kelly
Shreveport,
Ace Combustion Engr. Co.
MARYLAND,
Baltimore, J. J. Smith
MASSACHUSETTS,
Boston,
Monahan Pump Equip. Co.
MICHIGAN,
Detroit, Chicago Pump Co.
Grand Rapids,
C. H. Alexander
Saginaw, R. R. Kimble
MINNESOTA,
Minneapolis, Cash Co.
MISSISSIPPI,
Jackson,
Paine Machinery Co.
MISSOURI,
Kansas City,
J. M. O'Connor
Springfield,
Harry Cooper Supply Co.
St. Louis,
Foster Mechanical Equip. Co.
MONTANA,
Butte,
Sullivan Valve & Engr. Co.
NEW JERSEY,
Newark, R. B. Brown
NEW YORK,
Buffalo,
Bushnell-Felton, Inc.
New York,
Chicago Pump Co.
Rochester, R. C. Schwarz
Utica, H. F. Bantham
NORTH CAROLINA,
Greensboro, F. L. Bunker
OHIO,
Cincinnati,
C. R. Lingo Engr. Sales Co.
Cleveland,
Chicago Pump Co.
Columbus, J. T. Seiders
Toledo, M. C. Griffin
OKLAHOMA,
Oklahoma City,
Federal Steam Spec. Co.
OREGON,
Portland, D. R. Munro
PENNSYLVANIA,
Philadelphia,
Culbert-Whitby
Pittsburgh,
F. W. Rockstraw Co.
SOUTH CAROLINA,
Greenville, James McCabe
TENNESSEE,
Chattanooga,
Southern Sales Co.
Knoxville, S. T. Weaver
Memphis,
Southern Sales Co.
Nashville,
Southern Sales Co.
TEXAS,
Amarillo, Clowe & Cowan
Fort Worth,
Sprekelmeyer-McDonald
Houston, Dalton-Heyne Co.
San Antonio,
Dalton-Heyne Co
UTAH,
Salt Lake City,
L. Brandenberger
VIRGINIA,
Richmond,
Virginia Equip. & Supply Co.
WEST VIRGINIA,
Charleston, H. DeB. Miner
WISCONSIN,
Milwaukee,
Swisher Maurer & Co.
WASHINGTON,
Seattle, Chicago Pump Co.
Spokane, W. B. Starky

Vertical Condensation Pump and Receiver

Tables partial only (ask for Bulletin 133)

Unit No.	Maximum Sq. Ft. Direct Radiation	Lbs. Press. Pump will Disch. Against	Horsepower Motor Furnished	Capacity Pump in Gals. per Min.	Dia. Receiver, In.; also Floor Space
1650	3,000	10	½	5	24
1651	"	17	¾	"	"
1652	"	22	1	"	"
1654	6,000	10	½	10	24
1655	"	17	¾	"	"
1656	"	22	1	"	"
1658	10,000	10	½	15	24
1659	"	17	¾	"	"
1660	"	22	1	"	"
1662	15,000	14	¾	21	24
1663	"	18	1	"	"
1665	25,000	12	¾	35	30
1666	"	16	1	"	"
1668	40,000	10	¾	55	30
1669	"	14	1	"	"
1670	"	21	1½	"	"

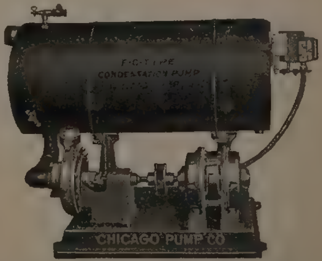


Vertical Condensation Pump

Fig. 1940

Horizontal Condensation Pump and Receiver

Designed for capacities up to 150,000 sq. ft. of direct radiation and boiler pressures to suit any job.



F. C. Condensation Pump Fig. 1931

ASK for BULLETINS 129, 131 and 133 for complete information and tables on Condensation Pumps.

"CONDO-VAC"

Condensation Vacuum

Vacuum and Boiler Feed Pumps

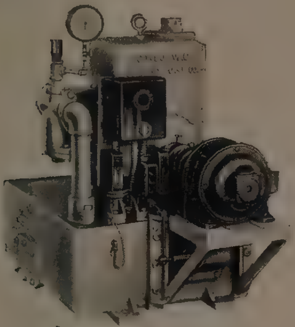


Fig. 1990. Single "Condo-Vac"

"Condo-Vac" is a Return-Line Condensation Vacuum and Boiler Feed Pump. It is a complete unit—having a base and receiver, motor, air and water pumps, float switch, vacuum regulator, automatic starter, strainer and pressure and vacuum gauges—completely wired and ready for installation as it leaves the factory.

"Condo-Vac" has a centrifugal air pump. Air and water pump are on one shaft, driven by one motor. Stuffing Boxes are free from vacuum or pressure—no injury to shaft caused by tight packing and no air drawn into pump through stuffing box. All fittings for pump interior are made of bronze. Inlet is very low—only 10 inches off floor on smaller sizes.

"Condo-Vac" is very quiet in operation. Oversize ball bearings used. Operating principle eliminates close clearances and their natural noises and early wear. Made in single and duplex units for systems up to 100,000 sq. ft. direct radiation and for pressures up to 35 lb. ASK for BULLETIN 137.

The Receiver of the "Condo-Vac," which also serves as a base, is made of cast iron. The construction of the receiver eliminates the necessity of a special foundation for the pump and forms an ideal base for the pump proper.

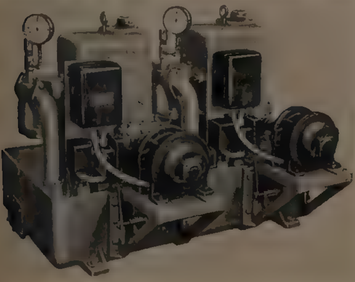


Fig. 1981. Duplex "Condo-Vac"

A heavy cast iron base carries the motor and is adjustable for various motor heights—base provides plenty of ventilation for motor. ASK for BULLETIN 137.

ARCHITECTS' SPECIFICATIONS DUPLEX "CONDO-VAC"

Furnish and install where indicated on plans, a duplex "Condo-Vac," centrifugal condensation and vacuum return line pump as manufactured by the Chicago Pump Company. This unit shall be a complete duplex pump mounted on one cast iron receiver together with all apparatus necessary for duplex automatic vacuum and float switch control.

Each pump shall have a capacity of .... sq. ft. of direct radiation and shall have a pressure of .... lb. at the pump discharge.

Cast iron receiver shall be so arranged that inlet will not be more than 12 in. from the floor. Pump casing shall be horizontally split. Suction strainer shall be placed between vacuum pump and receiver. Each pump shall be equipped with two out-board ball bearings.

Control apparatus shall include two enclosed, fused, main line switches, two enclosed float switches, two enclosed, automatic, vacuum switches, two manual vacuum cut out switches, and two enclosed automatic starters providing overload and low voltage protection. Each unit shall be controlled by its own vacuum switch and float switch, and piping and wiring shall be so arranged that either unit can be operated independent of the other.

All wiring and electrical connections between motors and control apparatus will be made when equipment is assembled at the factory. The entire pumping equipment is to be shipped from the factory in a complete unit, leaving only wiring between electrical service and motor and piping connections between inlet to receiver and discharge of pump to be done after pump has been shipped.

"CONDO-VAC" TABLES*

For 10 lb. Pressure at 1,720 r.p.m.

Unit No.	Sq. Ft. Direct Radiation	H.P. Motor for 10 lb. Pressure	Air Cap.—C.f.m., 10" Vacuum	Water Pump Capacity, G.p.m.	Size Return Inlet in Inches	Pump Discharge in Inches	Approx. Floor Space in Inches
2601	8000	1	5	12	2	1¼	48x56
2602	16000	1½	10	24	3	1¼	56x60
2603	26000	2	16	39	3	1½	60x62
2604	40000	3	21	60	4	2	66x62
2605	65000	5	36	96	4	2	74x66
2606	100000	7½	52	140	6	3	86x68
For 20 lb. Pressure at 1,720 r.p.m.							
2609	8000	1½	5	12	2	1¼	48x56
2610	16000	2	9	24	3	1¼	56x60
2611	26000	3	15	39	3	1½	60x62
2612	40000	5	19	60	4	2	66x62
2613	65000	7½	34	96	4	2	74x66
2614	100000	10	52	140	6	3	86x68

*Other tables for 35 lb. pressure in BULLETIN 137.

HORIZONTALLY SPLIT CENTRIFUGAL PUMPS—For all Purposes

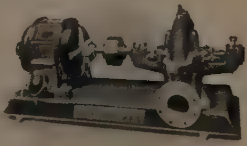


Fig. 1881 Type "D" Single Stage

Single and Multistage Centrifugal Pumps for hot or cold water circulating, boiler feed, booster and other work. Capacities up to 2,000 g.p.m. Pressures up to 310 lb. ASK for BULLETINS 101 and 103.

Economy Pumping Machinery Co.

3431 West 48th Place, **Chicago, Ill.**

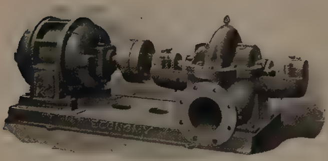
District Sales Offices

Baltimore, Md. ....522 Park Avenue
Boston, Mass. ....141 Milk Street
Chattanooga, Tenn. ....215 West 7th Street
Dallas, Texas ....2017 Cedar Springs Road
Detroit, Mich. ....517 E. Larned Street
Fort Wayne, Ind. ....225 E. Columbia Street
Indianapolis, Ind. ....Architects & Builders Bldg.
Jacksonville, Fla. ....660 College Street
Montreal, P. Q., Can. ....1072 Beaver Hall Hill

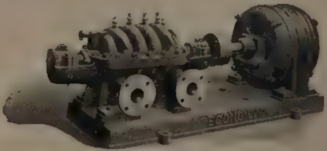
Economy Pumps

Horizontal Centrifugal

(For Clear Liquids)



Single-Stage



Multi-Stage

Horizontal Centrifugal Pumps are generally used for water supply, either with overhead tanks or directly into mains as boosters. They are also used for various other services, such as boiler feeding, hot water circulation, filter swimming pool circulation. They are truly general-purpose pumps.

The double-suction single-stage pumps embody up-to-date hydraulic developments with exceedingly high efficiencies. Their mechanical design is unusually rugged, so that they are fitted for continuous service. Specifications are given in Bulletin No. 408.

The high-pressure multistage horizontal split-case pumps have one-piece bronze diaphragms which eliminate leakage between stages. A volute or spiral in every stage results in high-pump efficiency without the use of diffusion vanes. The thrust is eliminated with a hydraulic balancing device. See Bulletin No. 414 for specifications.

Horizontal Centrifugal Pumps

Capacity Gal. per Min.	Total Head in Ft. Water	Size Disch. and Type of Pump	Motor Hp.	Number of Stages	Approx. Floor Space In.
20	30	1¼-SS	¾	1	16x30
20	115	1-AS	2	3	18x41
20	240	1-AS	5	6	18x46
50	20	1¼-SM	1	1	18x42
50	60	1¼-SM	2	1	18x42
50	175	1-AS	5	6	18x46
50	275	1-AS	10	4	22x54
100	30	2-SM	1½	1	20x46
100	100	2-MD	5	1	20x46
100	200	2½-EMF	10	4	24x62
100	500	2½-EMF	25	8	24x75
150	30	2½-SM	3	1	20x46
150	60	2½-SM	5	1	20x52
150	220	2½-EMF	15	4	24x62
150	300	2½-EMF	20	6	24x70
150	750	3-EMF	60	8	34x98
250	30	3-MF	3	1	22x48
250	125	2½-M	15	1	24x60
250	240	3-EMF	25	3	34x72
250	600	3-EMF	60	7	34x98
500	40	4-MG	7½	1	26x64
500	80	4-MG	15	1	26x64
500	200	3-ME	40	1	34x72
750	40	5-MH	10	......	26x64
750	200	5-M	75	......	34x84
1200	30	6-MJ	15	......	34x70
1200	200	5-M	100	......	34x98
3000	80	8-M	100	......	42x106
3000	140	8-M	150	......	48x112
3000	200	8-M	250	......	56x124

For intermediate sizes or sizes not listed refer to Bulletins No. 408, 414, 415 and 416.

Economy Pumping Machinery Co.

3431 West 48th Place, **Chicago, Ill.**

District Sales Offices—(Continued)

Cleveland, Ohio..............1603 St. Clair Ave., N. E.
New Orleans, La..........................807 Howard Avenue
New York City..............................39 Cortlandt Street
New York Central,
32 Pershing Drive, Scotia, N.Y.

Oklahoma City, Okla.........710 N. Hudson Street
Philadelphia, Pa..................................Bourse Bldg.
Pittsburgh, Pa......................................Fulton Bldg.
St. Louis, Mo...............................709 North Euclid Ave.
San Francisco, Calif..................Monadnock Bldg.

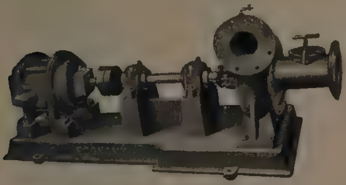
Non-Clogging Centrifugal Pumps

(For Pulpy Liquids)

Made in all sizes and capacities, both horizontal and vertical, for pumping raw sewage, industrial wastes, paper pulp, food pulps, etc. They are extensively used for ejection of sub-basement drainage from buildings, in municipal sewage lift stations, and in place of conveyors in industrial plants.

In addition to the pumps, we are in a position to furnish complete sewage pumping apparatus consisting of tanks, valves, fittings, piping, electric motors, automatic control, etc., all factory assembled and ready for erection. Our engineering department is in an excellent position to assist in the layout of such equipments, whether for buildings or municipalities.

Economy non-clogging pumps have several important patented features which make for longer life, lower maintainance cost. Write for Bulletins 412 and 413 describing them.


Horizontal Non-Clogging Pump

Duplex Submerged Non-Clogging Pump

Vertical Open Shaft

Selection Table Non-Clogging Pumps All Types

Capacity Gal. per Min.		Total Head in Feet 15	20	25	30	40	50
100	Size	3	3	3	3	4	4
	Horsepower	1½	1½	2	2	5	5
	Rev. per min.	1150	1150	1150	1150	1150	1150
150	Size	3	4	4	4	4	4
	Horsepower	2	3	5	5	5	5
	Rev. per min.	850	850	850	850	1150	1150
300	Size	4	4	4	4	4	4
	Horsepower	2	3	5	5	7½	10
	Rev. per min.	850	850	850	850	1150	1150
500	Size	4	6	6	6	6	6
	Horsepower	5	5	7½	7½	15	15
	Rev. per min.	850	850	850	850	1150	1150
750	Size	6	6	6	6	6	6
	Horsepower	7½	7½	10	10	15	20
	Rev. per min.	850	850	850	850	1150	1150
1000	Size	6	6	8	8	8	8
	Horsepower	7½	10	15	15	20	25
	Rev. per min.	850	850	850	850	850	850
1500	Size	8	8	8	8	8	10
	Horsepower	10	15	15	20	25	40
	Rev. per min.	670	670	670	850	850	850
2000	Size	8	8	10	8	8	10
	Horsepower	15	20	25	25	30	50
	Rev. per min.	670	670	670	850	850	850
3000	Size	10	10	10	10	10	10
	Horsepower	25	30	40	40	50	60
	Rev. per min.	670	670	850	850	850	850

We also manufacture a complete line of pumps for clear seepage in capacities from 7 g.p.m. up to 7,500 g.p.m.

Send for bulletins showing other speeds and capacities. The above is only a condensed table.

Use Hoffman Economy Vacuum and Condensation Pumps

See Pages 806-807 for Capacities

Goulds Pumps, Inc.

Seneca Falls, New York

New York, 16 Murray St. & 19 Park Place
Philadelphia..........111 N. Third St.
Boston..........194 Congress St.
Tulsa..........705 Kennedy Bldg.
Chicago..........12-14 S. Clinton St.
Cleveland..Union Trust Bldg.
Pittsburgh..........636 H. W. Oliver Bldg.
Atlanta..Citizen and Southern Bank Bldg.
Houston......1902 Second Nat'l. Bank Bldg.

Manufacturers of Pumps for Every Service

PRODUCTS—Centrifugal Pumps for all purposes—Single and Double Suction, Sump, Fire, Single and Multistage, Horizontal and Vertical. Triplex Pumps.

Single and Double Acting, Deep Well, Power Rotary, Pressure Pumps, etc.

Goulds Pumps, manufactured since 1848, comprise a line of hand and power pumps, including types and sizes for practically all pumping services.

Every Gould Pump sold is guaranteed to give reliable, satisfactory service under the conditions for which it is recommended.

The power pumps can be furnished for belt, chain, gear or direct drive from all types of drivers.

Condensation Return Pump and Receiver

Takes care of the condensation from heating plants up to 15,000 sq. ft. of direct radiation, based on ⅓ lb. of condensation per square foot per hour or 10,000 sq. ft. of radiation based on ½ lb. of condensation per square foot per hour. Outfits shipped from stock completely assembled.

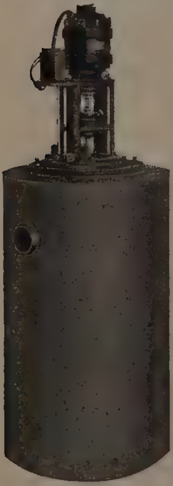


Fig. 3354

Pump—Ball bearing centrifugal type, two stage, bronze fitted. Requires no lubrication.

Pump Shaft and Float Rod—Operate through stuffing boxes to prevent leaks. This enables outfit to be used under pressure. Float Rod cannot bind.

Tank—Heavy, galvanized, welded steel, 24 in. in diameter by 40 in. high. Tank has two inlets both tapped for 3 in. pipe, 8 in. below top of tank. Tapped for vent connection, and fitted with drain opening. 1-in. discharge from pump to boiler.

Motor—½ hp. 1750 r.p.m., 110-220 volt, 60 cycle repulsion induction motor or ½ hp. 110 or 220 volt D.C. motor.

Capacity—20 gal. per minute; Maximum Direct Radiation, 15,000 sq. ft.; Maximum Discharge Pressure, 17 lb.; Height Overall, 64⅜ in.; Weight 350 lb.

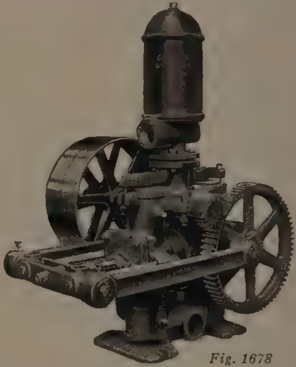


Fig. 1678

"Pyramid" Double Acting Power Pump

Sizes, Capacities, Etc.—(based on 200 ft. elevation). Made in five sizes, 2¼ x 4 in. to 5¾ x 6 in.; square foot of radiation, based on the condensation of one-third of a pound of steam per square foot of radiation surface per hour, 7500 to 75,000; for vacuum steam heat system, 700 to 7000 sq. ft. radiation; horsepower at catalog rating for cold water or condensation ½ to 5 hp., for vacuum steam heat systems ¼ to 1½ hp.; weight, 170 lb. to 980 lb.

When used as a condensate pump, a pump twice the required capacity should be selected so that pump will run intermittently. If temperature of water exceeds 160 deg. fahr. it must flow to the pump.

For handling condensation in connection with steam heating plants, hot water, mine service and general water supply.

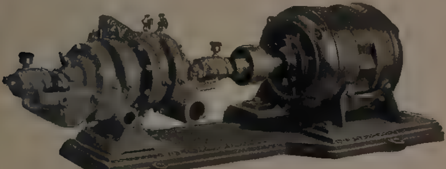
For Belt Drive—For heads up to 200 ft. With tight or loose pulleys.

For Gear Connection to Electric Motor—(Form C Drive). For heads up to 200 ft. Includes pump, cast iron bedplate, gear and pinion for connection to motor; motor not included.

Complete Outfit Including Electric Motor—(Form Q Drive). For heads up to 100 ft. Furnished only in the 2½ x 4 in. size. Includes pump, motor bracket, gear, pinion and motor.

Form Q Drive supplied with ¼ hp. motor, 110, 220, 32 volt D.C. motors and 110 or 220 volt A.C. motor, single phase. 60 cycles.

Four-Stage Centrifugal Pump



Standard Model—Fig. 3355

This New Standard Model is a 4-stage vertical split ball bearing pump for direct connection to electric motors. It is made in two sections with two pairs of opposed impellers which balance the thrust.

This pump covers an extremely wide range of capacities and heads making it suitable for use in connection with humidifying systems, for boiler feeding, as a house booster pump, for circulating brine, for handling gasoline and light oils, and other equipment requiring a circulating pump.

Bronze Fitted Pumps—Have bronze impellers, stainless steel shaft, bronze water seal rings and bronze bushings.

All Iron Pumps—Have all parts coming in contact with liquid of iron, except stainless steel shaft.

Pump size is 1 in.; r.p.m. from 1750 to 3450; capacities from 5 to 80 gal. per minute according to head; motors ¾, 1, 5 and 7½ hp.; domestic shipping weight 200 lb.; for bedplate for 5 and 7½ hp. motors add 30 lb.

Automatic Cellar Drainers

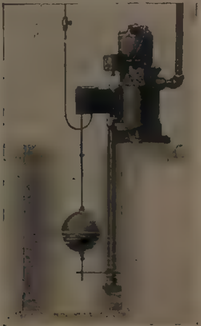


Fig. 1776

Vertical Self Priming Type—Fig. 1776. Capacities up to 25 gal. per minute. Heads up to 23 ft. For pit depths of from 1½ to 5 ft. Shipping weight 107 lb.

Pump has cast iron casing and priming chamber. Bronze impeller with stainless steel shaft working in bronze bearings. 1 in. discharge.

Motor is ¼ hp. mounted on pit cover. Furnished for 25 or 60 cycle A.C. or for D.C. circuits. Equipped with motor protecting Sentinel Breaker and 8 ft. of cord with plug. Double pole type switch. Copper float with brass rod.

Horizontal Self Priming Type—Fig. 3034. Two sizes, capacities 1 in. size up to 30 gal. per minute; 1½ in. size up to 50 gal. per minute. Heads up to 20 ft. Approximate weight, 100 and 250 lb.

This type is equipped with special priming chamber making it entirely automatic for pit depths of 3½ ft. Minimum diameter drainage pit, 1 in. size, 13½ in.; 1½ in. size, 16 in.

Pump is bronze fitted. Discharge 1 in. or 1½ in. Pump shaft is connected to motor shaft by flexible coupling. Motor is repulsion induction type. Double pole type switch. Copper float with brass rod.

Centrifugal Sump Pump—Fig. 3013 Electrically driven, directly connected to motor. Single stage, single suction. Used to elevate drainage in buildings to street level, where the basement floors, boilers and elevator pits are below sewer level, and for any other service where liquid accumulates in a catch basin, pit or tank. Pump casing and impeller are regularly made of close-grained gray cast iron. Capacities up to 600 gal. per minute, heads up to 70 ft. Motors, ½, ¾, 1, 2, 3, 5 and 7½ hp. Pit depths from 3 to 16 ft. Standard pit diameters, 36 in. and 42 in. Complete outfits includes Pump, Motor and Control Equipment. Also furnished for belt drive when electricity is not available. For pit depths up to 8 ft.

Centrifugal Sump Pump Fig. 3013

The Nash Engineering Company

Plant and General Offices

South Norwalk, Conn., U. S. A.

Sales Offices

ATLANTA	152 Nassau Street, N.W.
BIRMINGHAM	2224 Comer Bldg.
BOSTON	25 Huntington Avenue
BUFFALO	317 Chamber of Commerce
BUTTE, MONTANA	910 Arizona Street
CHATTANOOGA	1104 James Bldg.
CHICAGO	925 Monadnock Block
CLEVELAND	1600 Union Trust Bldg.
DALLAS	1020 Mercantile Bank Bldg.
DENVER	1226 California Street
DETROIT	Kerr Bldg.
INDIANAPOLIS	937 Architects & Builders Bldg.
KANSAS CITY, MO	314 W. Tenth Street
LOS ANGELES	1224 S. San Pedro Street
LOUISVILLE	901 Realty Bldg.
MEMPHIS	1714 Exchange Bldg.
MIAMI	113 N.E. Third Street
MINNEAPOLIS	808 La Salle Avenue
MONTREAL	417 New Birks Bldg.
NEW ORLEANS	344 Camp Street
NEW YORK, N. Y.	Graybar Bldg.
OKLAHOMA CITY, OKLA	1217 West 44th Street
OMAHA	Baum Bldg.
PHILADELPHIA	254 South 15th Street
PITTSBURGH	1430 Oliver Bldg.
PORTLAND, ORE	224 Pine Street
RICHMOND	301 American National Bank Bldg.
ST. LOUIS	4200 Forest Park Blvd.
SAN ANTONIO, TEX	412 Builders Exchange Bldg.
SALT LAKE CITY, UTAH	Dooly Bldg.
SAN FRANCISCO	Sharon Bldg.
SEATTLE	518 Fourth Avenue
TORONTO	90 Chestnut Street
VANCOUVER	410 Homer Street
WASHINGTON, D. C.	Barr Bldg.
WICHITA, KAN	808 Brown Bldg.

Return line and air line vacuum heating pumps. Condensation pumps. Standard and suction centrifugal pumps.

House service pumps. Sewage ejectors. Sump pumps. Compressors and vacuum pumps for air and gases.

Return Line Vacuum Heating Pump

Removes air and condensation from the return line of vacuum steam heating systems; discharges the air to the atmosphere and returns the water to the boiler.

Two independent units are combined in a single casing—an air unit and a water unit. Impellers of both are mounted on the same shaft. The pump is bronze fitted throughout.

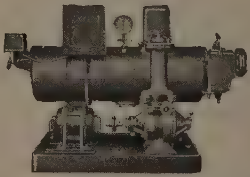
The air unit exhausts air and vapors and delivers these to the atmosphere without back pressure. The water unit removes condensation and pumps it directly into the boiler. Horsepower is saved, with a proportionate reduction in cost of current.

Supplied either direct connected to standard electric motors, for belt drive, or for steam turbine drive. For continuous or automatic operation against pressures up to 40 lb.

Capacities of Jennings Vacuum Heating Pumps

Pump Size	Equiv. Direct Rad. Sq. Ft.	Water Capacity G.P.M.	Air Capacity Cu. Ft. per	MOTOR H. P.			
				10 lb.	20 lb.	30 lb.	40 lb.
T	2500	4	3	⅓	½	1	1½
U	5000	9	3	⅓	½	1	1½
V	10,000	14	6	1	1	1½	2
B	16,000	22	9	1½	2	3	5
C	26,000	35	15	2	3	5	5
D	40,000	60	19	3	5	5	7½
E	65,000	90	34	5	5	7½	10
F	100,000	140	50	7½	10	15	15
*G	150,000	200	102	10	15	upon request	
*H	300,000	400	171	....	upon request		

*The last two sizes are not of the manifold type.



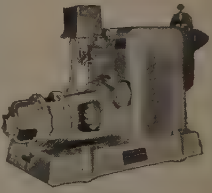
Jennings Motor-driven Return Line Vacuum Heating Pump

Condensation Pump and Receiver

Removes condensation from radiators in return-line steam heating systems and pumps condensation back to the boiler.

Compactness is secured by making the pump casing a part of the return tank, and bolting the motor base to the tank. The pump can be installed in a corner against the wall.

Jennings condensation pumps are furnished in standard sizes with capacities ranging from 4 to 22 g.p.m. of water. For serving up to 150,000 sq. ft. equivalent direct radiation.



Jennings Motor-driven Condensation Pump

Centrifugal Pump

For circulating hot and cold water; boosting city water pressure; handling water in air washing and conditioning; removing condensate from heating systems, blow-down from soot blowers and superheaters; exhaust drips from steam ejector air pumps and other auxiliaries; screen wash water, oil engine jacket water, ash sluicing water.

Compact—motor armature and pump impeller are mounted on the same shaft. Simplicity—no bearings in pump casing, only one stuffing box. Accessible—pump impeller can be removed without breaking pipe connections, touching packing, or disturbing shaft alignment.

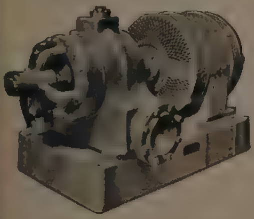
Jennings Centrifugal Pump

Supplied in 1¼, 1½, 2, 3, 4 and 6 in. sizes for handling up to 1200 g.p.m. Heads up to 250 ft. Bronze fitted pump is standard construction. Also furnished in all-bronze or all-iron for special service.

Centrifugal Pump Operating With Suction Lift

When the Jennings Suction Centrifugal is started, the built-in Nash Hytor Vacuum Pump exhausts the air from the casing and suction piping. Water is quickly drawn into the pump. Full rated capacity is delivered without delay.

Successful performance is assured under conditions where water level is likely to fall. Intermittent operation is possible without the need for a foot valve.



Jennings Suction (Self-Priming) Centrifugal Pump

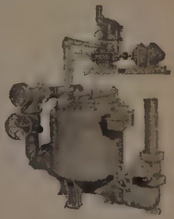
Furnished in 2, 3, 4 and 6 in. sizes for capacities up to 1200 g.p.m. Heads up to 100 ft. Either bronze fitted or all bronze construction.

Sewage Ejector

For pumping unscreened sewage or drainage from basements below the street sewer level; handling crude sewage from low level districts; pumping effluent, sludge and other heavy liquids.

The Jennings Sewage Ejector is of the pneumatic type. A Nash Hytor Compressor is used as the motive power to pump the accumulated sewage from a pot to the sewer.

Air is compressed, delivered, and used *only when* required. There are no air storage tanks, reciprocating air compressors, or screens. Air valves are avoided.



Jennings Sewage Ejector

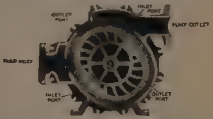
Furnished in standard sizes for handling from 30 to 1500 g.p.m. Heads up to 50 ft.

Compressors and Vacuum Pumps for Air and Gases

The rotor, consisting of a cylindrical hub around the periphery of which are chambers formed by heavy shrouds cast integrally, revolves in an elliptical casing filled with water.

As the rotor turns, it carries the water with it. The water under the influence of centrifugal force, follows the contour of the casing, and alternately enters and leaves the rotor chambers.

As the water recedes from the rotor, air is drawn into the chambers through the inlet port. As the water is forced back into the rotor, the air is compressed and then discharged through the outlet port.



Sectional View of the Nash Hytor Compressor or Vacuum Pump, Showing the Unique Principle of Hydro-Turbine Operation

A separator frees the compressed air of entrained moisture.

Supplied in standard sizes for handling up to 5000 cu. ft. of free air per minute. For discharge pressures up to 20 lb.; vacuums up to 20 in. of mercury column. Cast iron standard construction. Bronze fitted, solid bronze and other alloys furnished special.

Bulletins

No. 10. Nash Hytor Compressors.
No. 11. Mash Hytor Vacuum Pumps.
No. 52. Jennings Standard Centrifugal Pumps.
No. 85. Jennings Return-Line Vacuum Heating Pumps, manifold type.
No. 87. Jennings Vacuum Heating Pumps, unit manifold type.
No. 97. Jennings Suction Sump Pumps.
No. 99. Jennings Condensation Pumps.
No. 103. Jennings Sewage Ejectors, Type B.
No. 108. Jennings Sewage Ejectors, Type A.

The Rochester Circulator Company

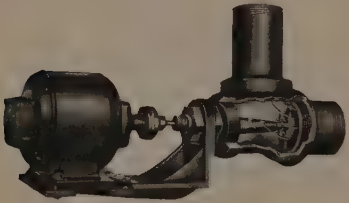
3092 Culver Road, P. O. Box 23

Rochester, N. Y.

The Rochester Circulator, for Hot Water Heating Plants, Domestic Hot Water Systems, Ice Water Circulation, or for circulating any liquid in a pipe system under a balanced head

---

Forced Circulation on every Hot Water Heating System represents the most modern method of obtaining efficient heating in all types of buildings. The equipment now made available to the Heating Engineer and Contractor, through the development of the Rochester Circulator, brings a remarkable improvement in existing heating plants, whether they be open systems or equipped with the latest pressure regulators.



With the Rochester Circulator installed practically full boiler temperature will be maintained through every part of every radiator and the boiler temperature will always be much lower than is possible without the Circulator. It is not necessary to maintain a big temperature differential between the flow and the return lines in order to secure circulation, while the effective average temperature at the radiator remains the same as before. This means much lower temperature of the escaping flue gas, and a corresponding economy in fuel consumption. Room temperatures are maintained practically constant, as the demand of the thermostat is met instantly in the radiator—there is no long time lag as invariably exists in a system depending on thermal circulation, pressure or otherwise.

Every radiator, regardless of its position relative to the boiler, is maintained at practically full boiler temperature from end to end, and from top to bottom, even though that radiator be served by flow and return pipes dipping below the boiler level, as in a separate building.

On new jobs the cost, including the Rochester Circulator, is less than without it, for the engineer has complete freedom in running his pipes past obstacles, etc., his calculations are greatly simplified, and usually smaller boilers and less radiation will amply take care of the maximum demand, due to the increased operating efficiency of the system.

On a sluggish system the Rochester Circulator is almost indispensible.

The first cost of the Rochester Circulator is low; its installation is very simple and inexpensive and its operating cost is very small. In fuel saving it will quickly pay for itself and its installation. It never interferes in the slightest degree with natural circulation, as the full area of all the flow or return pipes is maintained throughout. There are no flappers or check valves to corrode and stick.

The Rochester Circulator is made for every different pipe size, from 1½ to 12 in. All the return lines, or in some cases, the flow lines, are brought through one tee of equivalent size, installed as an elbow, and the Rochester Circulator screwed into the extra run opening of that tee, exactly like a pipe plug.

Sizes and Capacities of Rochester Circulator

Size and No.	Size of Tee	Plug	Motor H. P.	Shipping Weight	Nominal Capacity Gallons per Hour
1½	1½x1½x1½	1½	1/20	24	450
2	2x1½x2	1½	1/20	25	750
2½	2½x1½x2½	1½	1/20	26	1,500
3	3x2x3	2	1/20	27	2,700
3½	3½x2x3½	2	1/20	28	5,120
4	4x3x4	3	1/10	45	8,250
4½	4½x3x4½	3	1/8	47	10,000
5	5x3x5	3	1/6	50	13,500
6	6x6x6, 6x3 Bush.	3	1/4	65	16,500
7	7x7x7, 7x3 Bush.	3	1/3	100	18,000
8	8x8x8, 8x3 Bush.	3	1/3	125	21,000
10	10x10x10, Flanged	3	3/4	250	25,500
12	12x12x12, Flanged	3	1	300	36,000

NOTE.—6, 7 and 8 in. Circulators are shipped mounted in the corresponding Standard bushings; 10 and 12 in. Circulators are shipped mounted in Companion Flanges.

The nominal capacities, given in the table above represent one-half the pitch velocities of the standard marine propellers, and are much lower than the capacities obtained in actual average installations.

Write for full data and prices.

Skidmore Corporation

General Offices and Factory: 1535 Dayton Street, **Chicago, U.S.A.**

Sales and Service Offices

ATLANTA, GA.
BALTIMORE, MD.
BOSTON, MASS.
BUFFALO, N. Y.
CHARLOTTE, N. C.
CHICAGO, ILL.
CINCINNATI, OHIO
CLEVELAND, OHIO
DALLAS, TEXAS
DENVER, COLO.
DES MOINES, IOWA
DETROIT, MICH.
GARNET, N. Y.
GRAND RAPIDS MICH.
HOUSTON, TEXAS
INDIANAPOLIS, IND.
KANSAS CITY, MO.
LITTLE ROCK, ARK.
LOS ANGELES, CALIF.
MEMPHIS, TENN.
MILWAUKEE, WIS.
MINNEAPOLIS, MINN.
NASHVILLE, TENN.
NEW ORLEANS, LA.
NEW YORK, N. Y.
OKLAHOMA CITY, OKLA.
OMAHA, NEBR.
PEORIA, ILL.
PHILADELPHIA, PA.
PITTSBURGH, PA.
PORTLAND, ORE.
ROCHESTER, N. Y.
ROCKFORD, ILL.
SAN FRANCISCO, CALIF.
SEATTLE, WASH.
SPOKANE, WASH.
ST. LOUIS, MO.
TAMPA, FLA.
TOLEDO, OHIO
TULSA, OKLA.

Canadian Representatives and Manufacturers—DARLING BROS., LTD., MONTREAL, QUE.

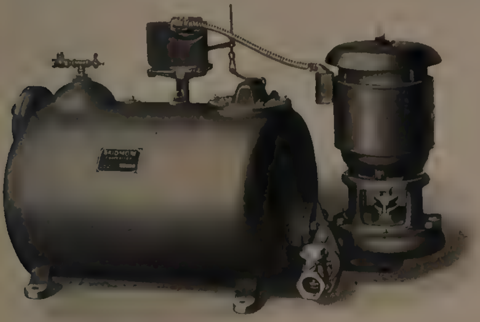


Illustration of Skidmore Condensation Pump

The Skidmore Condensation Pump

The same high-grade construction as in our Vacuum Pumps: bronze fitted throughout, cast iron tank, ball bearings. Due to novelty in design, pump has lower water-line control than many others which in many instances makes pitting unnecessary. Motor and float mounted high above danger of being submerged. Centrifugal pump is accessible without disturbing piping. *Send for Bulletin No. 7*

Size	Capacity Sq. Ft.	H. P. Motor 10 Lb.	H. P. Motor 20 Lb.	Gallons Between Float Stops	Gallons Per Minute Pumped	Inlet	Disc.	Weight 10#	Weight 20#
21	2,000	⅓	..	9	4	2"	1"	325	...
22	2,000	..	½	9	4	2"	1"	...	350
41	4,000	⅓	..	9	6	2"	1"	325	...
42	4,000	..	½	9	6	2"	1"	...	350
61	6,000	⅓	..	9	8	2"	1"	325	...
62	6,000	..	½	9	8	2"	1"	...	350
81	8,000	⅓	..	9	11	2"	1¼"	325	...
82	8,000	..	½	9	11	2"	1¼"	...	350
101	1,0000	⅓	..	18	13	2½"	1¼"	440	...
102	1,0000	..	½	18	13	2½"	1¼"	...	460
121	1,2000	½	..	18	16	2½"	1¼"	460	..
122	1,2000	..	¾	18	16	2½"	1¼"	...	470
161	1,6000	½	..	18	22	2½"	1¼"	460	..
162	1,6000	..	¾	18	22	2½"	1¼"	...	470
261	2,6000	¾	..	25	35	3"	1½"	495	..
262	2,6000	..	1	25	35	3"	1½"	...	515
401	4.0000	1½	..	25	60	3"	2"	525	..
402	4.0000	..	2	25	60	3"	2"	...	550

Skidmore Vacuum Pump

Interceptor base gives low water-line operation without pitting. Unit sets directly on floor—no necessity of a concrete base. Occupies small floor space, simple in design and sturdy, high efficiency. Having no close clearances, valves or gears, the **Efficiency Remains Constant.**

Send for Bulletin 6

Illustration of a Skidmore Automatic Vacuum Pump

10-in. Vacuum, 10 and 20 lb. Pressure

Size of Pump	Capacity Sq. Ft. of Radiation	Gals. of Water per Min.	Motor H. P. 10 Lb.	Motor H. P. 20 Lb.	Size of Companion Flanges for Returns	Size of Discharge to Boiler
0	5,000	8	¾	1	1½"	1"
1	8,000	11	1	1½	2"	1¼"
2	16,000	22	1½	2	2"	1¼"
3	26,000	35	2	3	3"	1½"
4	40,000	60	3	5	3"	2"
5	65,000	90	5	7½	5"	2"
6	100,000	150	7½	10	5"	2½"
7	150,000	200	10	15	5"	2½"

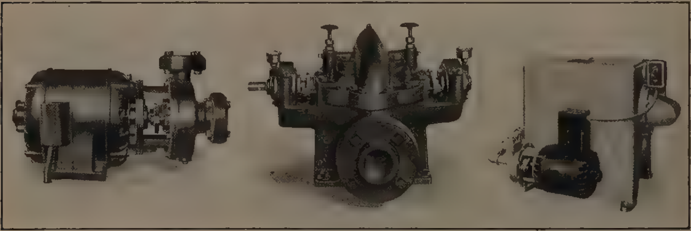
R. P. M. 1800 for all sizes. Data on pumps for higher discharge pressure furnished on request.

The Trane Company

La Crosse, Wis.

See Unit Heaters, page 679; Heat Cabinets pages, 654-655; Heating Specialties, pages, 838-839.
BRANCHES IN ALL PRINCIPAL CITIES

TRANE PUMPS



Circulating Pump *Heavy Duty Circulating Pump* *Condensation Pump, 400 Series*

The complete Trane Line of Pumps includes condensation pumps, sump pumps, circulating and booster pumps—both low and high pressure for water, brine, or liquids ordinarily encountered in the process industry.

All Trane pumps are of the centrifugal pumps. Due to advanced engineering design they develop higher efficiencies and require smaller motors than the average centrifugal pump. On the smaller pumps three-quarter horsepower motors do work that has always required one or one-and-one-half horsepower. On the larger pumps 7½ hp. motors do work that ordinarily requires a 10 hp. motor.

The condensation pump units are furnished completely hooked up and ready to install. All electrical equipment is wired according to National Code requirements.

Complete data, roughing-in dimensions and capacities for all sizes of pumps will be sent on request.

CAPACITIES

Pump No.	Radiation in Sq. Ft.	Min. Gal. per Min.	Max. Pres. at Pump	Motor H.P.	Unit Complete See Notes Approximate Ship. Wt., Lb.
410	4000	6–9	10	¼	250
415	4000	6–9	15	½	275
420	4000	6–9	20	½	275
430	4000	6–9	30	¾	275
440	4000	6–9	40	¾	300
610	6000	9–12	10	¼	400
615	6000	9–12	15	½	425
620	6000	9–12	20	½	425
630	6000	9–12	30	¾	450
640	6000	9–12	40	¾	450
810	8000	12–16	10	¼	400
815	8000	12–16	15	½	425
820	8000	12–16	20	½	425
830	8000	12–16	30	¾	450
840	8000	12–16	40	¾	450
850	8000	12-16	50	2	550
1010	10000	15–20	10	¼	425
1015	10000	15–20	15	½	450
1020	10000	15–20	20	½	450
1030	10000	15–20	30	¾	475
1040	10000	15–20	40	¾	475
1050	10000	15-20	50	2	650
1510	15000	25–30	10	½	525
1515	15000	25–30	15	¾	550
1520	15000	25–30	20	¾	550
1530	15000	25–30	30	1	575
1540	15000	25–30	40	2	625
1550	15000	25–30	50	3	650
2010	20000	30–40	10	¾	550
2015	20000	30–40	15	1	575
2020	20000	30–40	20	1	575
2030	20000	30–40	30	2	625
2040	20000	30–40	40	2	625
2050	20000	30–40	50	3	650
2510	25000	40–50	10	1	575
2515	25000	40–50	15	1	575
2520	25000	40–50	20	1½	600
2530	25000	40–50	30	2	625
2540	25000	40–50	40	3	650
2550	25000	40–50	50	3	650

Data on larger sizes will be furnished upon request.

Schleicher, Inc.

Factory: **Gary, Indiana**

Manufacturers of Slyker Metal Radiator Furniture

SLYKER

Representatives in all Principal Cities

Specialists in the manufacture of Radiator Enclosures for Cast Iron Radiators, Free standing floor types, Wall mounted or Recessed. Finned type radiators, including Recessed Linings and Paneled fronts. Housings and tops for Fantom radiators. Housings for Industrial heat units. Access Panels to plumbing and heating pipes or other concealed equipment to which quick access is desired

From a report (Bulletin 192) entitled "Investigation of Steam Radiators with Enclosures and Shields by A. C. Willard, A. P. Kratz, M. K. Fahnestock and S. Konzo, all of the University of Illinois" appearing in the June 1st and 15th issues of *Domestic Engineering*, we quote the following:

"23. Performance of Enclosures—A Comparison of the six types of commercial enclosures tested may be made from Table 3. From this table it is evident that the most satisfactory combination of all of the factors involved was obtained with enclosure No. 3. Since the degree of comfort produced is probably the final criterion for judging the performance of any given heating unit, the mean temperature in the zone from the floor to the breathing level is the most important factor involved. With one exception, the highest mean temperature below the breathing level was obtained with enclosure No. 3."

Detailed drawings—architects size—for the asking. Tell us your problem and we will illustrate the answer.

"We Say It With Drawings"

Access Panel Model A showing anchor straps and plaster grabs

Type C J—2 recessed lining and grill for finned radiation

Housing for industrial type unit heater

ROME BRASS RADIATOR CORPORATION

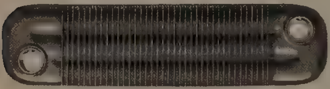
1 East 42nd Street, **New York**

BOSTON CHICAGO CLEVELAND PHILADELPHIA PITTSBURGH ST. LOUIS

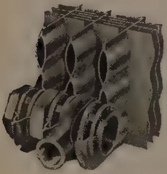
Representatives in Principal Cities

Robras 20-20 finned type radiators are scientifically designed non-corrosive extended surface radiators, especially developed to utilize the advanced principles of heating, wherein the heat-surface is enclosed, either within the building wall or a casing.

Robras Radiators utilize the enclosure as a stack within which they induce a positive movement of the heated air, expelling it *horizontally*, with sufficient velocity to insure a uniformity of heating throughout the adjacent space never before achieved without fans. Thus the Rome Brass Radiator Corporation endorses this modern Method of Heating as incomparably superior to former practice, affording uniform comfort, economy, effective control, freedom from enormous weight and bulk, and freedom from intrusion upon the decorative scheme.



Robras Finned Type Radiators are made entirely of brass and so constructed that they will withstand ordinary steam pressures. As indicated two stamped brass side plates are electrically welded around the edges and down the center in two places. The brass radiating fins are applied at right angles to the surface. Shouldered nipples between sections are firmly screwed into octagonal spacers to prevent distortion of the brass walls. End caps are screwed on to the shouldered nipples at each end section.



Robras Radiators are sectional as described and the sections are assembled in one or two tiers according to the space available. They may be any number of sections deep. By the use of special fittings sections may be connected vertically or horizontally as illustrated.

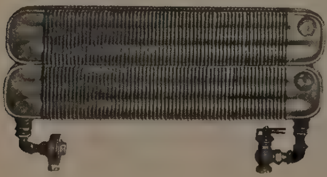
Sections of Robras Radiators are from 18 to 70 inches in length and are conservatively rated from 5½ sq. ft. to 25 sq. ft. so that 100 sq. ft. of Robras Radiator can be set in a space 4 in. deep, 12 in. high and 70 in. long.

The ratings of Robras Radiators have been determined from carefully prepared tests and are guaranteed, when radiators are properly installed, and other conditions of the heating plant are correct.

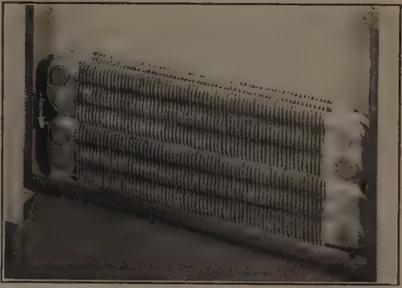
Robras 20-20 radiators are rated E. D. R. (Equivalent Direct Radiation). Their ratings in square feet are given on Pages 770 and 771.

Special attention is called to the fact that, due to their construction and the method of rating, it is *unnecessary* to increase Robras 20-20 radiation 25 per cent, or any other quantity, because of the enclosure.

When the amount of radiation to be installed is known, determine the recess space available. Suppose that it is required to install 42 sq. ft. E. D. R. in a recess under a window. The approximate recess dimensions are 40 in. long by 24 in. high by 6 in. deep. The draft head can be determined by subtracting approximately 10 in. from the available height of the wall space to provide for top and bottom grilles and overlap of enclosure. In this case, the approximate draft head would be 12 in. and reference should be made to table on Page 770 under this heading. Select a section length nearest to the length of recess available and refer to capacities under length of section and opposite 5¼ in. depth of radiator. This would give a rating of 31½ sq. ft., which is insufficient and a two-tier radiator should, therefore, be selected. By using the above method and referring to tables on Page 771 a rating of 42 sq. ft. will be found for a radiator 32 in. long and 5¼ in. deep which would meet the requirements. The space requirements for installing valves and traps must be considered. If used on a two-pipe system, the supply connection could be horizontal and the return vertical. If used on a one-pipe system, supply connections could be either vertical or horizontal.



If an intermediate draft head is available, that is, one between any of those shown in this catalog, the footage may be estimated for that particular height as the heat output of any radiator increases proportionally with the increase in draft head and vice versa.



An important feature to be kept in mind, is that any type of front used *must have two openings*, one at the floor line, the other at the top of enclosure, preferably in the front face. In no case must the front be made of one large grille. Such a front prevents the proper circulation of air and cuts down the effectiveness of the radiator, unless backed by a sheet of metal or other material to form a proper flue.

Where *connections looking down* are used, at least one inch of space is needed at the ends of the radiator, that is, the recess need be only two inches longer than the section. Recess lengths for other assemblies may be determined by reference to pages 8 to 11 of our catalog and adding necessary length to accommodate valves and traps.

Typical Specifications for Robras Radiators

Robras Radiators Furnish and install where shown on plans and called for in the specifications, ROBRAS Radiators of the finned type as manufactured by the ROME BRASS RADIATOR CORPORATION, 1 East 42nd Street, New York City.

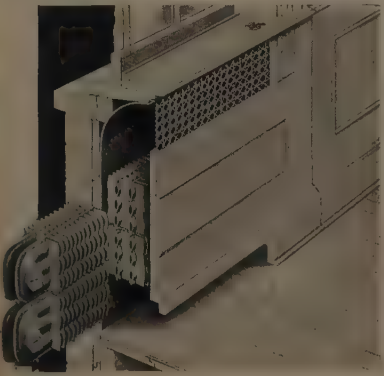
All radiators shall be shipped completely assembled with the connections tapped in accordance with the manufacturers' schedule.

All ROBRAS Radiators shall be installed in a horizontal position with the low end generally 4 in. above the finished floor and shall be pitched in accordance with dimensions furnished by the manufacturers.

Radiators may be supported on standards made of ⅜ in. iron nipples with a floor flange at either end.

Radiator Recesses

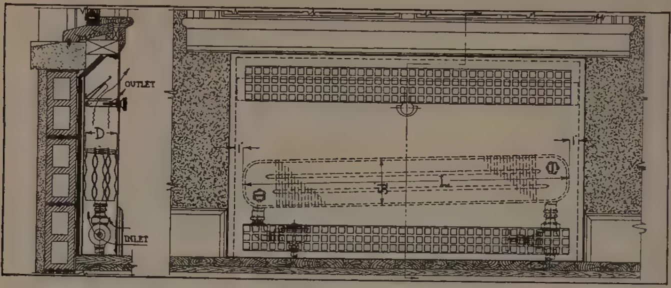
All recesses for ROBRAS radiators shall be lined with No. 26 gauge sheet metal, backed with approved insulation. Sizes of recesses shall be as shown on plans, but general details may be obtained from the ROME BRASS RADIATOR CORPORATION Engineering Catalog. (Where desirable, our enclosures or lining and fronts separately can be used.)



Radiator recesses shall be provided with fronts having face openings above and below the radiator as shown on details. The Free Area of the bottom opening or grille shall be not less than 30 per cent of the top face area of the radiator. The Free Area of the top opening or grille shall be not less than 40 per cent of the top face area of the radiator. (The top face area of the radiator is its depth from front to back multiplied by the section length).

Bathroom Units

Each bathroom unit shall be furnished complete with a white lacquered metal cabinet 8 in. high and may be supported by the pipe connections only. (Note that on one-pipe steam jobs small angle iron brackets will be required for these units). ROBRAS Bathroom Units shall be so installed as to have the grille at the top.



Typical One Tier ROBRAS 20–20 Installation Showing Front Elevation and Section

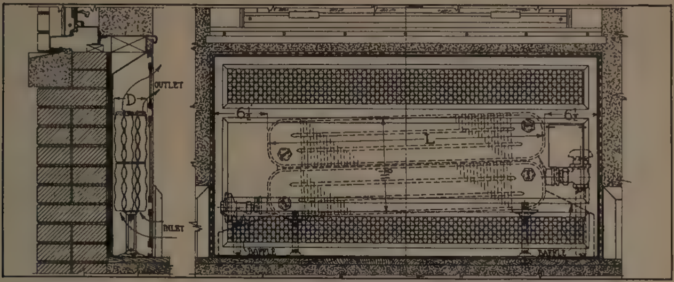
Capacities of Enclosed ONE TIER
ROBRAS 20-20 Radiators

Capacities are shown in the square foot equivalent of standard direct cast iron radiation. One square foot equals 240 B.t.u. per hour in a 70 deg. room with steam at 215 deg. and one pound pressure

DRAFT HEAD is measured from bottom of radiator to bottom of OUTLET GRILLE

L—Section Length		18″	22″	26″	32″	38″	44″	50″	60″	70″
Total Number of Sections in Rad.	A—Face to Face of Tappings 1″ Tap	19¾″	23¾″	27¾″	33¾″	39¾″	45¾″	51¾″	61¾″	71¾″
	A—Face to Face of Tappings 1½″ Tap	20½″	24½″	28½″	34½″	40½″	46½″	52½″	62½″	72½″
	D—Overall Depth of Rad.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.
12 in. Draft Head										
2	3¾″	9	11½	13½	17¼	21	24½	28	34	40
3	5¼″	13½	17¼	20¼	25¾	31½	36¾	42	51	60
4	6¾″	18	23	27	34½	42	49	56	68	80
5	8¼″	22½	28¾	33¾	43	52½	61¼	70	85	100
6	9¾″	27	34½	40½	51½	63	73½	84	102	120
18 in. Draft Head										
2	3¾″	9½	12½	15	19	22½	26½	30½	37	43½
3	5¼″	14¼	18¾	22½	28½	33¾	39¾	45¾	55½	65¼
4	6¾″	19	25	30	38	45	53	61	74	87
5	8¼″	23¾	31¼	37½	47½	56¼	66¼	76¼	92½	108¾
6	9¾″	28½	37½	45	57	67½	79½	91½	111	130½
24 in. Draft Head										
2	3¾″	10½	13½	16	20	24½	29	33	40	47
3	5¼″	15¾	20¼	24	30	36¾	43½	49½	60	70½
4	6¾″	21	27	32	40	49	58	66	80	94
5	8¼″	26¼	33¾	40	50	61¼	72½	82½	100	117½
6	9¾″	31½	40½	48	60	73½	87	99	120	141
30 in. Draft Head										
2	3¾″	11	14	17	21½	26	30½	35	42½	50
3	5¼″	16½	21	25½	32¼	39	45¾	52½	63¾	75
4	6¾″	22	28	34	43	52	61	70	85	100
5	8¼″	27½	35	42½	53¾	65	76¼	87½	106¼	125
6	9¾″	33	42	51	64½	78	91½	105	127½	150

Where top outlets are used, decrease amount of required effective radiation 10 per cent and use capacities shown above.



Typical Two Tier ROBRAS 20–20 Installation Showing Front Elevation and Section

Capacities of Enclosed TWO TIER
ROBRAS 20-20 Radiators

Capacities are shown in the square foot equivalent of standard direct cast iron radiation. One square foot equals 240 B.t.u. per hour in a 70 deg. room with steam at 215 deg. and one pound pressure.

DRAFT HEAD is measured from bottom of radiator to bottom of OUTLET GRILLE

L—Section Length		18"	22"	26"	32"	38"	44"	50"	60"	70"
	A—Face to Face of Tappings 1¼" Tap	20"	24"	28"	34"	40"	46"	52"	62"	72"
	A—Face to Face of Tappings 2" Tap	21"	25"	29"	35"	41"	47"	53"	63"	73"
Total Number of Sections in Rad.	D—Overall Depth of Rad.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.
12 in. Draft Head										
4	3¾"	14½	18	22	28	34	40	45½	55	65
6	5¼"	21¾	27	33	42	51	60	68¼	82½	97½
8	6¾"	29	36	44	56	68	80	91	110	130
10	8¼"	36¼	45	55	70	85	100	113¾	137½	162½
12	9¾"	43½	54	66	84	102	120	136½	165	195
18 in. Draft Head										
4	3¾"	16½	20½	25	31½	38½	45	51½	62½	73½
6	5¼"	24¾	30¾	37½	47¼	57¾	67½	77¼	93¾	110¼
8	6¾"	33	41	50	63	77	90	103	125	147
10	8¼"	41¼	51¼	62½	78¾	96¼	112½	128¾	156¼	183¾
12	9¾"	49½	61½	75	94½	115½	135	154½	187½	220½
24 in. Draft Head										
4	3¾"	17½	22½	27½	34½	41½	49	56	68	80
6	5¼"	26¼	33¾	41¼	51¾	61¼	73½	84	102	120
8	6¾"	35	45	55	69	83	98	112	136	160
10	8¼"	43¾	56¼	68	86¼	103¾	122½	140	170	200
12	9¾"	52½	67¾	82½	103½	124½	147	168	204	240
30 in. Draft Head										
4	3¾"	19½	24½	30	37½	45½	53½	61	74½	87½
6	5¼"	29¼	36¾	45	56¼	68¼	80¼	91½	111¾	131¼
8	6¾"	39	49	60	75	91	107	122	149	175
10	8¼"	48¾	61¼	75	93¾	113¾	133¾	152½	186¼	218¾
12	9¾"	58½	73½	90	112½	136½	160½	183	223½	262½

Where top outlets are used, decrease amount of required effective radiation 10 per cent and use capacities shown above.

James B. Clow & Sons

(ESTABLISHED 1878)

General Offices: 211 N. Talman Avenue, **Chicago, Illinois**

Manufacturers of CLOW GASTEAM RADIATORS

Sales Offices

CLOW GASTEAM HEATING COMPANY:

Baltimore, Md.	718 N. Howard Street
Birmingham, Ala.	1131 S. First Street
Boston, Mass.	250 Stuart Street
Buffalo, N. Y.	991 Main Street
Charleston, W. Va.	407 Broad Street
Clarksburg, W. Va.	14 Arcade Bldg.
Cleveland, Ohio	1076 Union Trust Bldg.
Dallas, Texas	2009 Main Street
Detroit, Mich.	1311 Buhl Bldg.
Fort Worth, Texas	808 First Nat'l. Bank Bldg.
Houston, Texas	2919 Main Blvd.
Huntington, W. Va.	1414 Fourth Avenue
Jacksonville, Fla.	230 Adair Bldg.
Kansas City, Mo.	8 West 10th Street
Lexington, Ky.	107 Barr Street
Little Rock, Ark.	215 Home Ins. Bldg.
Lubbock, Texas	307 Temple Ellis Bldg.
Louisville, Ky.	811 E. Broadway
New York, N. Y.	2276—12th Avenue
Norwood, Ohio	2702 Melrose Avenue
Oakland, Calif.	363 Hobart Street
Parkersburg, W. Va.	520 Avery Street
Philadelphia, Pa.	506 Bailey Warehouse Bldg.
Pittsburgh, Pa.	502 Wabash Bldg.
San Antonio, Texas	1111 Broadway
San Francisco, Calif.	571 Mission Street
San Jose, Calif.	123 S. Third Street
Tampa, Fla.	3822 San Juan Street
Wichita, Kans.	225 S. Main Street

Representatives

Coshocton, Ohio	*M. C. Smotzer*	James B. Clow & Sons
Dayton, Ohio	*613 Mutual Home Bldg.*	Bacon & Saunders
Los Angeles, Calif.	*1865 W. Cordova Street*	Williams Radiator Co.
New Orleans, La.	*618 S. Peters Street*	Dawson Heating Co.
Oklahoma City, Okla	*12 W. Main Street*	Gasteam Radiator Co.
Phoenix, Ariz.	*131 E. Harrison St.*	Dale Shreeve
Shreveport, La.	*249 Rutherford Avenue*	Barrow Heating Co.
Toledo, Ohio	*5838 Lakeside Avenue*	H. E. Turner
Tulsa, Okla.	*329 E. Fourth Street*	Gasteam Radiator Co.

Clow Gasteam Radiators

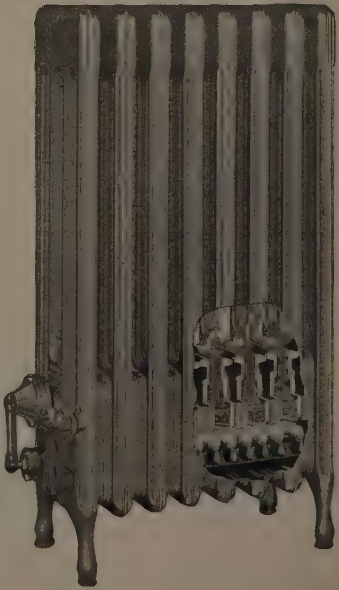
A unit steam heating system, using gas fuel, suitable for heating a single small room or an entire large building. Notable installations include the International Nickle Company, Huntington, W. Va.; South Water Market, Chicago; Metro-Goldwyn-Mayer Studios, Culver City, California.

Clow Gasteam radiation combines the advantages of gas fuel and steam heat with greatest operating efficiency.

Each Gasteam radiator is a complete heating unit in itself. There is no central boiler, steam piping, or water piping. Below the steam columns is a gas burner, completely enclosed in cast iron. An automatic regulator maintains a running steam pressure of approximately 5 lb. A filling cap permits periodic replenishing of the water chamber, necessary every two to four weeks.

Independent operation of each Gasteam radiator makes possible large fuel economies not possible with a centrally operated heating plant.

Only those Gasteam radiators need be used **when** and **where** heat is needed. Quick steam heat is always ready for short periods, or for continuous operation, without starting up the whole heating system. No heat is wasted in an unused basement, or in long steam transmission lines. Furthermore, because no central



boiler, or fuel storage space must be provided, the need for a basement is largely eliminated. Or, in buildings already built, this basement space can be used to much better advantage for other purposes.

Approved

Clow Gasteam is listed as standard by the Underwriters Laboratories and approved by the American Gas Association Testing Laboratory. Rigid tests by health departments and municipal boards also have resulted in their being unconditionally approved. (See City of Baltimore, Smith Emery, E. Vernon Hill and Rice Institute Test Data).*

Vented and Unvented

Unvented Clow Gasteam radiators deliver the moisture produced by the combustion of gas directly into the room air. This is highly desirable in dry climates, making additional humidification unnecessary.

In relatively damp or cold climates this additional moisture is undesirable. Vented Clow Gasteam radiators dispose of the moisture they produce through a vent connection and stack to the outside air. Generally it is not necessary to provide for all vented radiators in an installation. Except in very damp or very cold climates, where all vented radiators should be provided, a combination of vented and unvented Clow Gasteam radiators will prevent excess moisture.

	No. of Sections	Equiv. Sq. Ft. of Radiation
Four-Tube Unvented 38 Inches High	4	32
	6	48
	8	64
	10	80
	12	96
	15	120
Four-Tube Unvented 26 Inches High	4	20
	6	30
	8	40
	10	50
	12	60
	15	75
Four-Tube Unvented 22 Inches High	4	12
	6	18
	8	24
	10	30
	12	36
	15	45
Six-Tube Unvented 31 Inches High	2	28
	3	40
	4	53
	5	65
	6	77
	7	89
	8	101
	9	113
	10	125
Six-Tube Unvented 26 Inches High	2	22
	3	32
	4	43
	5	53
	6	63
	7	72
	8	82
	9	91
	10	100
Four-Tube Vented 38 Inches High	5	28
	7	39
	9	50
	11	61
	13	72
	15	83
	20	110
	25	137
Four-Tube Vented 26 Inches High	5	15
	7	21
	9	27
	11	33
	13	39
	15	45
	20	60
	25	75

---

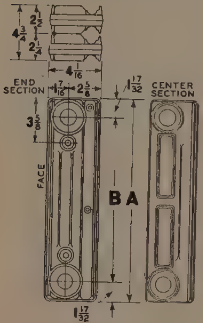
*Send for A. I. A. No. 29, f. 4 Catalog, "Clow Gasteam Heating Systems," free on request.

National Radiator Corporation

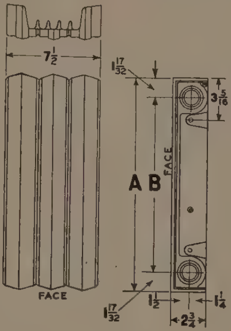
General Offices: **Johnstown, Pa.**

NATIONAL PANEL RADIATION

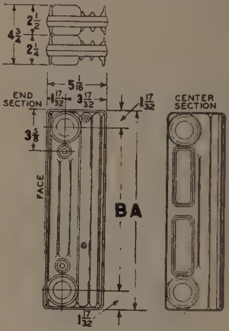
NATIONAL Panel Radiators are designed for installation beneath windows of Public Buildings, Office Buildings, Apartment Houses, Hospitals, Schools and Dwellings. They can be installed flush with or recessed in the wall, thereby saving valuable floor space.



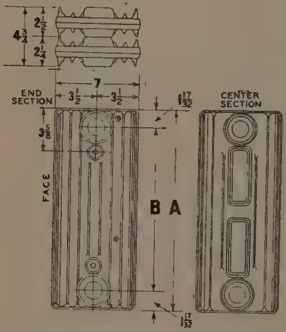
1-Tube



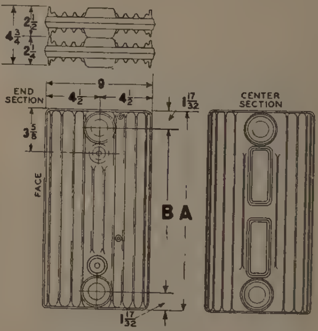
2-Tube



3-Tube



4-Tube



5-Tube

STYLE	1-TUBE		2-TUBE		3-TUBE		4-TUBE		5-TUBE	
	17 in.	23 in.	17 in.	23 in.	17 in.	23 in.	17 in.	23 in.	17 in.	23 in.
Dimension A........	17″	$22\frac{3}{4}''$	17″	$22\frac{3}{4}''$	17″	$22\frac{3}{4}''$	17″	$22\frac{3}{4}''$	17″	$22\frac{3}{4}''$
Dimension B........	$13\frac{15}{16}''$	$19\frac{11}{16}''$	$13\frac{15}{16}''$	$19\frac{11}{16}''$	$13\frac{15}{16}''$	$19\frac{11}{16}''$	$13\frac{15}{16}''$	$19\frac{11}{16}''$	$13\frac{15}{16}''$	$19\frac{11}{16}''$
Sq. Ft. per Section...	$1\frac{3}{4}''$	$2\frac{1}{4}''$	$3\frac{1}{3}''$	$4\frac{1}{4}''$	2″	$2\frac{2}{3}''$	$2\frac{2}{3}''$	$3\frac{1}{3}''$	$3\frac{1}{4}''$	4″

Interchangeable for Steam or Water.
TAPPINGS: 1½ inch top and bottom both ends. Bushed to meet requirements.
CONNECTIONS: Assembled with extra heavy Malleable Iron Push Nipples.
VENTS: All Panel Radiators regularly furnished with Steam and Water Vents.
Guaranteed Heat Emission of 240 B.t.u. per square foot listed rating in room temperature of 70° F. with steam at 215° F.
Diameter of rod holes ½ in.

National Bonded Boilers and National Aero Radiators are described on pages 598, 599 and 600

Healy-Ruff Company

Manufacturers of E-Z Radiator Hangers and Concrete Inserts

776 Hampden Avenue, **St. Paul, Minn.**

PRODUCTS

E-Z One-Bolt Radiator Hanger or Bracket, for hanging all makes of wall and tube radiation.

E-Z Concrete Inserts, for all pipe hangers.

E-Z RADIATOR HANGERS

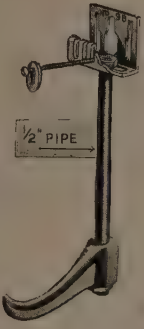
Style "R" places radiator 1½ in. from wall, but is not adjustable for baseboard adjustment.

All Style "R" hangers convertible, with parts No. 5 and No. 8, into Style "H."

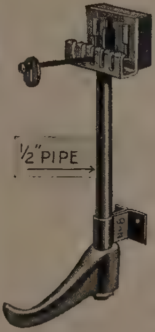
Both styles are made for wall, column and tube radiation.

All parts made of pressed steel except bottom hook support.

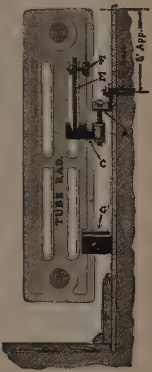
All column and tube radiation is held in at the top with an invisible washer.



Style R



Style H



Style C

Advantages

Easy to clean under the radiator.

Anchor bolts can be placed in walls during construction. No accurate measurements required since hangers have both horizontal and vertical adjustments. (Vertical adjustments on styles H and R made with ½ in. pipe).

Only one bolt in the wall for each hanger.

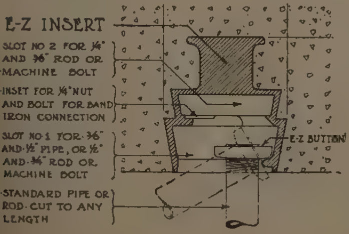
Expansion can not affect anchor bolts in wall.

Entire hanger invisible when installed.

Adjustable for any height of baseboard.

Saves time and labor.

Applicable to walls of wood, brick, tile or of any other material.


E-Z INSERT
SLOT NO 2 FOR ¼" AND ⅜" ROD OR MACHINE BOLT
INSET FOR ¼" NUT AND BOLT FOR BAND IRON CONNECTION
SLOT NO 1 FOR ⅜" AND ½" PIPE, OR ½" AND ¾" ROD OR MACHINE BOLT
STANDARD PIPE OR ROD CUT TO ANY LENGTH
E-Z BUTTON

Style "C" hanger will hang tube radiation, wall radiation, and the new "fantom" radiation. Fully adjustable horizontally and vertically and has adjustments for irregular walls. Can be furnished for hanging either 1½ or 2½ in. from wall. Style "C" is a complete hanger, no nipples being required. All parts made of pressed steel.

Typical Specifications

All radiation, unless otherwise noted, shall be supported on wall by means of E-Z Radiator Hangers, Style—— or equal, and approved in writing by the architect, arranged to support the radiator—— in. from the wall.

E-Z Concrete Inserts (7 in 1)

An insert with special features making it adaptable to all sizes of pipe hangers, whether supported by pipe, bolt, rod or band iron.

Advantages—Made in just one size, and this one size accommodates ¼, ⅜, ½ in. pipe, ¼, ⅜, ½, ⅝ and ¾ in. rod or bolt.

Ball and socket connection between insert and hanger.

Fully Adjustable—Allows play to compensate for expansion and inaccurate alignment of inserts. E-Z Button turns in the insert—no couplings or turn-buckles needed.

"Make Pipe Hanging Easy."

York Ice Machinery Corporation

General Office

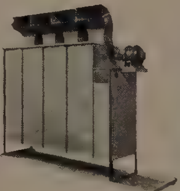
York, Pa.

Direct Sales and Service Branches in Principal Cities

Complete Refrigerating and Air Conditioning Installations for all Types and Sizes of Industrial and Commercial Applications

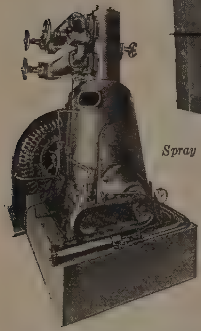
---

Spray Type Air Conditioner



Coil Type Air Conditioner

Air Washer



Vertical Single Acting Semi-enclosed Carbon Dioxide Compressor

Coil Type Air Conditioner:

A self-contained unit for cooling air by means of water, brine, carbon dioxide, methyl chloride or ammonia. Coil design insures maximum efficiency. Low speed fans designed for quiet operation. All parts galvanized. Exterior casing lacquered finish. Adapted to thermostatic control with defrosting feature.

Spray Type Air Conditioner:

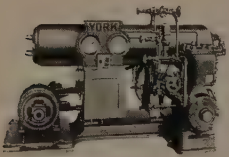
Complete self-contained air conditioning unit requiring minimum space and including air washer with refrigerating coil air heating coils, fan and motor, pump and motor and temperature and humidity control, all assembled as a single unit.

Air Washer:

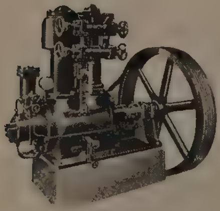
Galvanized iron copper and copper air washers of extra heavy construction, especially designed for refrigerating duty for water or brine. Washers furnished with or without coils. Adjustable self-cleaning mist nozzles insure maximum humidifying efficiency.

Refrigerating Equipment:

Complete ammonia and carbon dioxide refrigerating plants of capacities suitable to any commercial installation. The design of York compressors provides minimum clearances in the compressor working cylinders, low lift, large area valves, automatic lubrication of all bearing surfaces, quiet operation and a minimum amount of expert attention.



Complete Self-Contained Refrigerating Unit



Vertical Single Acting Enclosed Ammonia Compressor

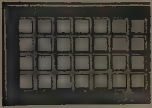
The Auer Register Co.

Cleveland, Ohio

MANUFACTURERS OF REGISTERS, FACES AND GRILLES FOR HEATING AND VENTILATING; WROUGHT METAL GRILLES FOR CONCEALING AND PROTECTING RADIATION

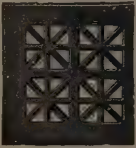
Cold Rolled Steel, Sheet Brass, and Bronze, any Size

10 Gauge and Lighter Steel in all Standard Finishes, 12 Gauge most popular



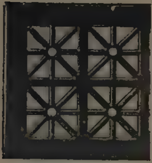
PLAIN LATTICE DESIGN

Design No.	Holes	Bars	Opening
8A	½" sq.	¼"	50%
5A	¾" sq.	¼"	64%
3A	⅞" sq.	¼"	70%
9A	1" sq.	¼"	75%
10A	1¾" sq.	¼"	85%



UNION JACK

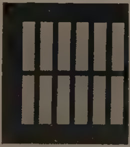
Design No.	Squares	Bars	Multiples
12A	2½"	¼"	2¾" sq.
	2½"	½"	3" sq.
14A	3"	⅜"	3⅜" sq.
	3"	½"	3½" sq.
16A	3⅝"	⅜"	4" sq.
	3⅝"	⅝"	4¼" sq.
20A	4⅛"	⅜"	4½" sq.



GRECIAN CROSS

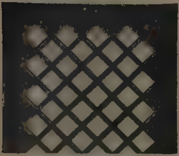
Design No. 7A, 50% Opening

Squares	Bars	Multiples
3"	⅜"	3⅜" sq.
3"	½"	3½" sq.
3"	¾"	3¾" sq.

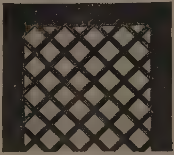


OBLONG MESH

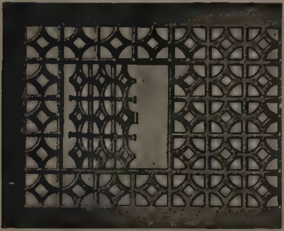
No.	Opening	Bars	Opening
15A	1½ x ¾	¼"	67%
17A	2¾ x ¾	¼"	72%



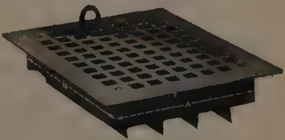
DIAGONAL MESH
No. 6A
¾ in. sq. holes
¼ in. bars



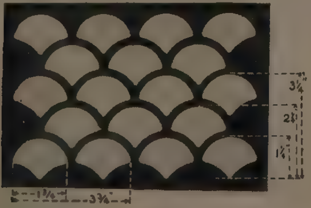
DIAGONAL
With fractional Mesh around margin.
Designated as **No. 18A.**



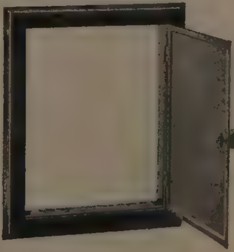
No. 4A Moorish Design, 51% Opening
Openings 1¾ in. Bars ¼ in. Multiples 2 in. sq.



LOUVER REGISTERS
In all sizes and finishes for all purposes. The above shows Pole operating Register.



SHELL DESIGN—Design No. 13A, 50% Opening



Metal Doors for Clothes Chutes, Switch Boxes, etc.

Invisible doors for access to radiator valves can be incorporated.
All grilles can be made into registers with operating or stationary louvers.

Tuttle & Bailey Mfg. Co.

Established 1846

441 Lexington Avenue, New York

Boston..........36 Portland Street
Chicago..........407 S. Dearborn Street
Kansas City..........704 East 18th Street
San Francisco..........Phelan Bldg.

TUTTLE & BAILEY MFG. CO. of Canada, Ltd., Bridgeburg, Ontario, Can.

Send for "GRILLES"—a textbook on choosing, layingout and fastening all types of grilles

Registers—

All types of standard registers in stock. Special sizes and brass and bronze registers in plain lattice and special designs—to order.

Grilles—

Perforated of steel, brass, bronze, Monel metal and aluminum sheets, in several designs to sizes specified.

Grilles (Ferrocraft)—

Cast of iron, brass and bronze metals, in plain lattice and decorative designs.

Ferrocraft Cast Iron Grilles have the latitude in design that makes it possible to harmonize radiator concealment with the decorative plan of the room, and by their delicacy of line in metalcraft add distinction to the interior furnishing.

Ferrocraft Cast Grilles in Period designs, combining the artistic with the practical, are offered to discriminating Architects and Engineers as the solution for covering ducts and concealing radiators, to the satisfaction of those who appreciate the best.

They are made to specification of size, material, design and finish. Our catalog **"GRILLES"** illustrates more than 150 different designs.

Radiator Cabinets—

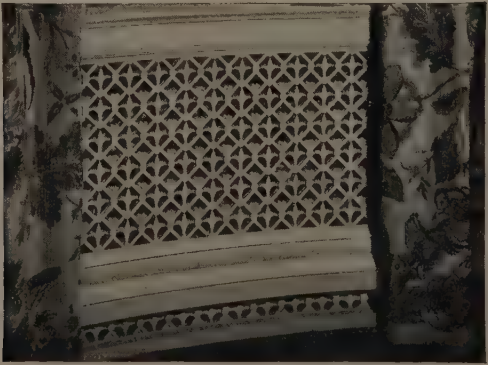
Many attractive styles made of furniture metal and designed to meet both technical and artistic requirements. To order only, to fit any radiator and surrounding conditions.

Radiator Fronts—

For recessed radiators, in attractive designs and with or without new type Sliding damper for easy air control.

Fixed Louvres—

Of stamped steel; design and construction of the *National Board of Fire Underwriters.*

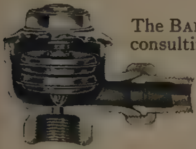


Ferrocraft Grille—Design 121

Barnes & Jones

128 Brookside Avenue, **Jamaica Plain, Boston, Mass.**
New York Office: 101 Park Avenue

Barnes & Jones Improved Modulation Vapor and Vacuum Systems of Steam Heating; Modulating Radiator Valves; Thermostatic Radiator Traps; Thermostatic Traps for medium and high pressures; Condensators (Boiler Return Traps); Blast Traps; Drip Traps; Vent Traps; Strainers; Damper Regulators; Gages.



Barnes & Jones Service

The Barnes & Jones organization offers an advisory and consulting service, believing that the manufacturer of a heating system often is in the best position to give practical assistance in the solution of heating problems. On request, members of our staff will consult with and advise engineers, contractors or users as to the most advantageous manner in which Barnes & Jones apparatus can be installed and operated. When desired, our Service Department will furnish installation details and work with engineers, contractors or users to gain the best results in installation or operation.

Barnes & Jones Modulation Valves

Made in the angle type, in sizes from ½ to 1½ in. Renewable disc seat.

Size Valve, Inches	Capacity, Sq. Ft.
½	30
¾	60
1	100
1¼	180
1½	250

Barnes & Jones Vent Traps

Vent Trap

The air from a Barnes & Jones Vapor System is discharged to the atmosphere through a Barnes & Jones Vent Trap, with a float valve to prevent discharge of water and ball check valve to allow free discharge of air but prevent its return into the system, thus enabling Barnes & Jones Vapor Systems to operate in many cases under vacuum conditions, with a resultant saving in fuel.

Barnes & Jones Condensators

For returning the water of condensation to the boiler from open return line systems independently of boiler pressure, without change in operating conditions, without air binding, or admitting steam to the return side.

No. 1 Condensator at left

Blast Drip Trap at right

B. & J. Thermostatic Radiator Traps

Made in ½, ¾, 1 and 1¼ in. sizes.

Size Valve, Inches	Water per Hour, Lb.	Sq. Ft. Coils	Sq. Ft. C. I. Radiation
½	30	100	125
¾	80	240	320
1	200	600	800
1¼	400	1200	1600

Barnes & Jones Blast Traps

Combination float and thermostatic traps with an air and water capacity large enough to take care of the condensation from the largest vento stacks, dry kiln coils, hot water heaters and other units condensing large quantities of steam at low pressures. Made in sizes from 1 to 2½ in. Capacities to 5000 lbs. of water per hour.

Blast Trap

B. & J. Blast-Drip Traps, Type BD

For use on drips from supply mains and risers and on returns from water heaters and indirect stacks. Float-controlled valve governs discharge of water; thermostatically-controlled valve allows passage of all air but prevents passage of steam. Made with ¼ in. tappings.

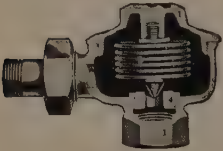
The Bishop & Babcock Sales Co., Cleveland, Ohio

4901-4915 Hamilton Avenue, N.E.

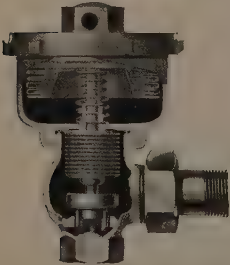
BALTIMORE, MD.........Building Service Co., 404 St. Paul St.
BIRMINGHAM, ALA., Quin W. Stuart, American Traders Bk. Bldg.
BOSTON, MASS......................The Bishop & Babcock Sales Co.
BRIDGEPORT, CONN.................E. A. Seeley, 55 Calvin Street
CHATTANOOGA, TENN.........S. Roberts, 215 West 7th Street
CHICAGO, ILL..........................The Bishop & Babcock Sales Co.
CINCINNATI, OHIO, Cooper Pogue, 930 Chamber of Commerce Bldg.
DENVER COLO.................The Daly Co., 1635 Blake Street
DETROIT, MICH.........W.-Hawley & Co., 6032 West Fort St.
DULUTH, MINN.....The C. C. Ferguson Co., 809 Torrey Bldg.
LOS ANGELES, CALIF., Mr. John Dowd, A-65 Chamber of Commerce Bldg.
MEMPHIS, TENN.......M. T. Crumley, 1366 S. Lauderdale St.
MINNEAPOLIS, MINN.........The Bishop & Babcock Sales Co.
NEW YORK, N. Y..............The Bishop & Babcock Sales Co.
OKLAHOMA CITY, OKLA.............. Federal Steam Specialty Co.
PHILADELPHIA, PA., Alexander & McDevitt, 2313 Walnut St.
PITTSBURGH, PA.................The Bishop & Babcock Sales Co.
RICHMOND, VA...................Virginia Equipment & Supply Co.
SCOTIA, N. Y............................F. E. Dwyer, 32 Pershing Dr.
SPOKANE, WASH..................................Heating Assurance, Inc.
WASHINGTON, D. C...........Edward A. Maginnis, Bond Bldg

Heating Specialties—Temperature Control—Ventilating Equipment—Unit Heaters

Special Modulation Valve



B. & B. Multiflex Trap No. 6



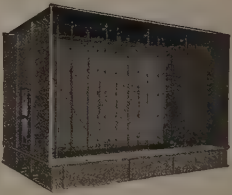
Multiflex Pneumatic Radiator Valve

All Metal Thermostat

Bishop & Babcock manufactures a complete line of Heating and Ventilating Equipment. Its products comprise all devices and apparatus used in up-to-date vacuum and vapor Heating Systems, Temperature Control and Ventilating Systems. It is entirely practical for an engineer and architect to standardize with **Bishop & Babcock** apparatus, thus insuring a uniformity in design and operation not to be found in equipment of varied manufacture.

Bishop & Babcock has been manufacturing heating, ventilating and temperature control apparatus for many years; its installations including many of the most prominent buildings in all parts of the country.

Our Engineering Data Book, pocket edition, will be mailed upon request.



Type B Massachusetts Air Washer

Single Width Squirrel Cage Fan

Type C Unit Heater (Ceiling)

Type V Unit Heater (Floor)

Cochrane Corporation

3120 North 17th Street, **Philadelphia, Pa.**

Branch Offices

Atlanta, Ga.
Baltimore, Md.
Boston, Mass.
Charlotte, N. C.
Chicago, Ill.
Cincinnati, Ohio
Cleveland, Ohio
Denver, Colo.
Detroit, Mich.
Harrisburg, Pa.
Hazleton, Pa.
Houston, Texas
Indianapolis, Ind.
Joplin, Mo.
Kansas City, Mo.
Knoxville, Tenn.
Los Angeles, Calif.
Memphis, Tenn.
Minneapolis Minn.
New Orleans, La.
New York, N. Y.
Oklahoma City, Okla.
Phoenix, Ariz.
Pittsburgh, Pa.
Portland, Ore.
Richmond, Va.
Rochester, N. Y.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Calif.
Scranton, Pa.
Seattle, Wash.
Syracuse, N. Y.
Toronto, Ont.
Montreal, Que.
Halifax, N S.
Calgary, Alta.
Winnipeg, Man
Havana, Cuba
Paris, France

ENGLAND, Norman Engineering Co., 23 Budge Row, LONDON

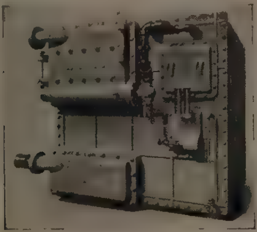
PRODUCTS—Open Feed Water Heaters; Closed Heaters; Deaerating Heaters; Metering Heaters; Hot Process Water Softeners; Pressure Filters; Steam and Oil Separators; Steam Purifiers; Back Pressure Valves; Drainers or Traps; Dischargers; Blow-off Valves; Flow Meters for steam or water in pipes; V-Notch Meters; Automatic Boiler Blow-off Systems; Automatic Returns Vent Traps, etc.

Slogan: *"To Economize, Cochranize."*

Feed Water Heaters

The Cochrane open heater heats the water to steam temperature and serves as a hot well or return tank and as an automatic cold water regulator.

Storage heaters of both direct contact and surface types are supplied.



Combined Deaerator and Hot Water Generator

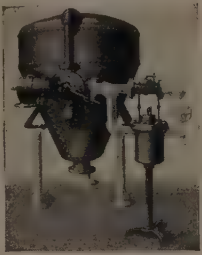
Deaerators

Deaerators heat the water and expel oxygen and other gases from water and thereby prevent corrosion in piping, economizers, boilers and heating systems. They cure the "red water" trouble. Cochrane Combined Deaerators and Hot Water Generators have been specially designed for low basement engine and boiler rooms.

Steam and Oil Separators

remove liquids or solids from steam. Steam separators protect engine or turbine, increase efficiency and improve lubrication. Oil separators make exhaust steam as good as low pressure live steam.

Steam and Oil Separator



Pressure Filter with Single Control Valve

Stainerless Conical Filters

A new improved design for clarifying water for drinking, washing, swimming pools, industrial processes, boilers, etc.

Multiport Back Pressure Valves

Multiport Back Pressure Valve

These valves differ from the ordinary back pressure valves in that a number of small disks are used instead of one large disk, thus reducing the size, weight and travel of the disks and insuring absolute safety.

Traps and Drainers

The Cochrane Drainer removes condensate or drips from low or high pressure heating or drying coils, radiators, jackets, steam and oil separators, etc. Due to the balanced valve it has tremendous discharge capacity, exceeding 600,000 lb. per hr. The Cochrane automatic returns vent trap voids air from vacuum pump while holding pressure on condensate so that it will flow to heater.

Drainer

Combustion Specialties Corporation

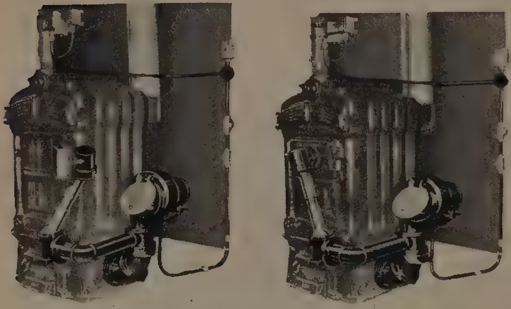
101-109 East 144th Street, New York

Manufacturers

BURN BUCKWHEAT **DRAFT-BALANCER** LOWER COSTS

DRAFT **COMBUSTO** SYSTEM

For all types and sizes of Heating and Hot Water Supply boilers in Apartment Houses, Buildings, Churches, Garages, Greenhouses, Institutions, Schools and Residences.



DRAFT-BALANCER installation with Mercoid Automatic Control and Manual Cut-Out Switch showing operation of Double Ball and Socket Joints with Telescoping Sleeve

Specifications:

Consists of cast iron or aluminum housings bolted directly to ash-pit of boiler. Damper door over intake controls volume of air delivered by Sirocco fan wheel. Fan is direct connected to Century, G. E., or Leland motor. A portion of the air delivered by the fan is diverted over the fire by piping or metal flexible hose from orifice in adapter casting to double ball and socket telescoping coupling. This air is delivered to diffuser on inside of fire-door and sprayed over the fire for consuming the monoxide gas as it is distilled from the coal. Operation is governed by Mercoid or Contactor type of automatic control.

The DRAFT-BALANCER enables the *burning of Buckwheat No. 1 coal without increasing the tonnage consumed or attention necessary to the fire* over that required with the use of Egg, Stove, Nut, or Pea anthracite. This is due to the unique feature of creating a balanced air supply over and under the fire, together with the carefully studied-out engineering principles which assure positive, accurate, quiet operation.

WHAT COMBUSTO IS: To quote the late Walter S. Timmis, past president of the *American Society of Heating & Ventilating Engineers:* "COMBUSTO is a system carefully studied, tested and developed for each individual different case and provides means for supplying the necessary diffused and heated air (oxygen) over the fire to properly complete in the second stage the combustion begun in the fuel bed by distillation of gases."

WHAT COMBUSTO DOES: "COMBUSTO is of cast iron cellular structure, the air is heated on passing through this structure and is then discharged through a large number of small apertures over the fire bed. The amount of air thus admitted having been carefully computed for the required conditions, the result is practically perfect combustion, which to the user of COMBUSTO results in—

Economy of fuel
Fewer firings
Complete combustion of fuel, hence—
A finer ash and reduction of clinker
Elimination of coal gases
Means for producing a steady even heat."

STYLES: COMBUSTO is manufactured in 28 basic styles—each style is capable of adjustment to meet specified conditions. Suitable styles are manufactured for practically any type of heating plant and for all sizes and grades of fuel. Definite estimates can be submitted at once if manufacturer's name and number of boiler is sent to us.

COMBUSTO
Saves coal and labor—maintains even heat with less draft
Aids draft with undersize chimneys

G. M. Davis Regulator Company

407 MILWAUKEE AVENUE :-: CHICAGO, ILL.
New York Office, 71 Fulton Street
Manufacturers of Automatic Valve Specialties

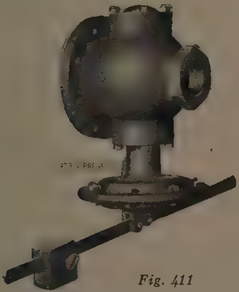
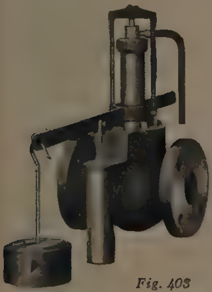


Fig. 411

Pressure Regulator—Diaphragm Type

Large diaphragm insures sensitive action under low service pressures as required in heating.



Pressure Regulator—Piston Type

Automatically makes any pressure reduction. Has visible action and may be hand tested.

Fig. 408

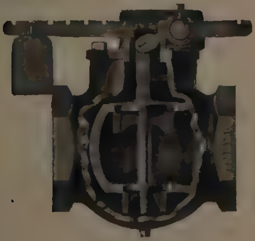


Fig. 425

Back Pressure Valve

A noiseless, double ported, semi-balanced valve for maintaining exhaust steam pressure of 20 lb. or less.

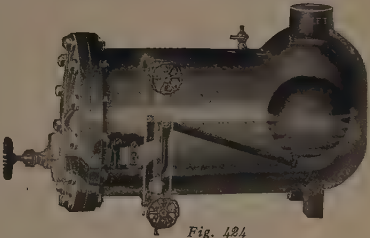


Fig. 424

Steam Trap—Continuous Flow Type

Duplex balanced valves give unusually large capacity. Works on any pressure without alteration. Will discharge into a vacuum line.

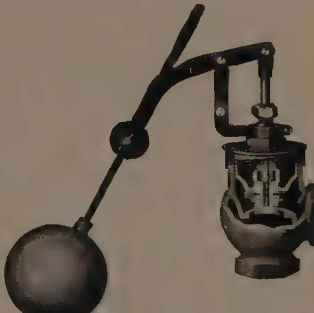


Fig. 419

Float Valve—Globe and Angle Patterns

Used on makeup line to open tank—maintains constant level. Has no internal packing—closes tight. Can not stick.

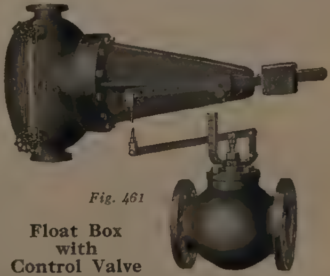


Fig. 461

Float Box with Control Valve

An accessible unit for controlling the level in a closed tank. Made also for distant control.

C. A. Dunham Company

General Offices: Dunham Bldg., 450 East Ohio St., **CHICAGO, ILL.**

Factories: Marshalltown, Iowa, Michigan City, Indiana and Toronto, Ont., Can.

Special Sales Office, Washington, D.C. (Munsey Bldg.), Col. W. H. Riblet

Eastern Division Offices
101 Park Avenue, New York, N.Y.

Central Division Offices
450 E. Ohio Street, Chicago, Ill.

Western Division Offices
617 W. 7th Street, Los Angeles, Calif

SALES OFFICES

EASTERN DIVISION

Albany, N.Y., 91 State St.
Allentown, Pa., 11 S. 5th St.
Baltimore, Md., 218 Water St.
Bangor, Maine, 104 Exchange St.
Boston, Mass., 136 Federal St.
Buffalo, N.Y., 232 Delaware Ave.
Clarksburg, W.Va., 212 Exponent Bldg.
Greensboro, N.C., 915 American Bank Bldg.
Greenville, S.C., P. O. Box 563
Harrisburg, Pa., 2216 N. Fifth St.
Huntington, W.Va., 530 First Huntington National Bank Bldg.
Johnstown, Pa., 244 Market St.
Kingston, Pa., 302 Kingston Corners Bldg.
Newark, N.J., 972 Broad St.
New Haven, Conn., 30 Whitney Ave.
New York, N.Y., 101 Park Ave.
Philadelphia, Pa., 1500 Walnut St.
Pittsburgh, Pa., 3002 Grant Bldg.
Poughkeepsie, N.Y., 38 Fulton Ave.
Providence, R.I., 49 Westminster St.
Rochester, N.Y., 972 Mercantile Bldg.
Syracuse, N.Y., 306 O. C. S. B. Bldg.
Trenton, N.J., 219 E. Hanover St.
Washington, D.C., 327 Munsey Bldg.
White Plains, N.Y., 199 Main St. (Bar Bldg.)

CENTRAL DIVISION

Special Sales Office, 450 East Ohio Street, Chicago, C. E. Roscoe

Akron, Ohio, 1175 La Croix Ave.
Atlanta, Ga., 804 Forsyth Bldg.
Birmingham, Ala., 1216 Martin Bldg.
Chattanooga, Tenn., 1201-03 Volunteer Bldg.
Cheyenne, Wyo., 430 Boyd Bldg.
Chicago, Ill., 450 East Ohio St.
Cincinnati, Ohio, 1231 Union Trust Bldg.
Cleveland, Ohio, 430 Terminal Tower Bldg.
Colorado Springs, Colo., 1424 E. Platte Ave.
Dallas, Texas, 408 Dallas National Bank Bldg.
Davenport, Iowa, 305 Security Bldg.
Denver, Colo., 414 West Colfax Ave.
Des Moines, Iowa, 710 Old Colony Bldg.
Detroit, Mich., 2988 E. Grand Blvd.
Duluth, Minn., 316 Glencoe Bldg.
Grand Rapids, Mich., 1003 Grand Rapids Trust Bldg.
Houston, Texas, 911 Electric Bldg.
Indianapolis, Ind., Board of Trade Bldg.
Ironwood, Mich., 6 Albert Bldg.
Joliet, Ill., P. O. Box 1086
Kansas City, Mo., 615 City Bk. Bldg.
Louisville, Ky., 1342 Starks Bldg.
Memphis, Tenn., 355 Madison Ave.
Milwaukee, Wis., 901 Empire Bldg.
Minneapolis, Minn., 132 So. 10th St.
New Orleans, La., 419 Maritime Bldg.
Omaha, Neb., 527 Peters Trust Bldg.
Peoria, Ill., 1303 Peoria Life Bldg.
Quincy, Ill., 628-638 Jersey St.
St. Louis, Mo., 3605 Laclede Ave.
San Antonio, Texas, 3005 Smith-Young Tower
Toledo, Ohio, 1918 Vermont Ave.
Wichita, Kan., 1100 E. Douglas Ave.

WESTERN DIVISION

El Paso, Texas, 401 N. Santa Fe St.
Kalispell, Mont., Whipps Block
Los Angeles, Calif., 617 W. 7th St.
Portland, Ore., 1000 Buyers Bldg.
Salt Lake City, Utah, 204 Dooly Bldg.
San Francisco, Calif., 232 Monadnock Bldg.
Seattle, Wash., 312 Securities Bldg
Spokane, Wash., 614 Peyton Bldg

C. A. Dunham Co., Ltd.,
1523-41 Davenport Road,
Toronto, 4, Ont., Canada.

Sales Offices: Calgary, Alta.; Halifax, N.S.; Montreal, Que.; Ottawa, Ont.; Quebec, Que., St. Johns, Nfld.; Toronto, Ont.; Winnipeg, Man.; Vancouver, B.C.

C. A. Dunham Co., Ltd.
(of The United Kingdom)
18 St. Thomas St., S.E. 1, London, England.

Agencies: Birmingham, Eng.; Leeds, Eng.; Liverpool, Eng.; Newcastle-on-Tyne, Eng.; Glasgow, Scotland; Belfast, Ireland; Paris, France; Munich, Germany; Copenhagen, Denmark; Gothenburg, Sweden; Wellington, N.Z. -

---

The DUNHAM
Difr-enshal-Vacm
Heating System
A FIXED DIFFERENTIAL IN PRESSURE
A VARIABLE DEGREE OF VACUUM

The DUNHAM
HEATING SERVICE

This Service is delivered through over eighty Sales Offices throughout the United States, Canada and the United Kingdom. These Branch and Local sales offices bring Dunham Heating Service as close to your office as your telephone. Consult your telephone directory for the address of our office in your city. An engineer will counsel with you on any project.

DUNHAM DIFFERENTIAL VACUUM HEATING SYSTEM

Heating with Steam of Variable Temperatures—Cool Steam (133 deg. fahr.) Warm Steam (133 deg. to 212 deg. fahr.); Hot Steam (Above 212 deg. fahr.)

Principles and Design

The principle of the Dunham Differential Vacuum Heating System is based on the fundamental laws of heat flow and heat processes. The basis of the theory is briefly summed up in the statement of its object—to maintain steady temperatures inside a building throughout the heating season, irrespective of the daily and hourly fluctuations of the outside weather.

No Complicated Equipment Required

The Differential Vacuum Heating System accomplishes this without any complicated or delicate equipment, or any greater variety of appliances than is used by the ordinary Vacuum Return Line Heating System. No larger or special Boiler is required on this system than on any other. Any type of Boiler suitable for heating work and of high efficiency can be used.

Easily Adaptable to Change-over From Existing Vacuum Return Line Systems

An ordinary, well-designed, Vacuum Return Line System can be changed-over to the Dunham Differential System. Radiation does not have to be disturbed and in most instances existing piping may be used with only slight changes.

The system uses steam as a heating medium. Steam is supplied at variable temperatures from 133 deg. up to 212 deg. and higher if so required. The 133 deg. temperature corresponds to 25 in. of vacuum (at sea level), and 212 deg. to zero on the gauge. By furnishing steam at this wide range of temperatures, it is possible to vary the heat output of the radiation thus preventing overheating.

Based on Bed-Rock Laws of Physics

This system is simple in design, easy to install and very economical in operation.

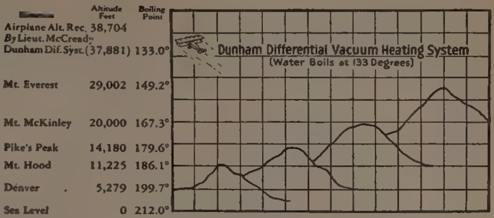


Fig. 1220A

No new principle is used to attain the long sought combination of comfortable heat, with real economy. The application of the Dunham Appliances which utilize this important principle is the only thing new. These appliances are *attention—compelling and revolutionary*. They have made the Dunham Differential Vacuum Heating System the outstanding heating development of the decade.

The temperature of the steam is governed by the Dunham control equipment and the Dunham Differential Vacuum Pump, which removes the air from the system, thereby reducing the pressure on the water in the boiler, or causing the steam to expand through Reducing Valves when they are used.

The term "Differential" is applicable because a relatively constant differential in pressure between the radiator and the return is maintained, so that the air and water will constantly flow out of the radiators. The steam is induced to completely fill them. Due to this "Differential" complete circulation is obtained and the radiators throughout the building are heated uniformly.

THE HEAT EMITTED BY A RADIATOR DEPENDS ON THE TEMPERATURE DIFFERENCE BETWEEN THE RADIATOR AND THE AIR OF THE ROOM.

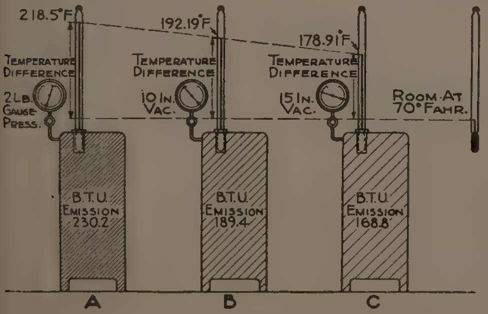


Fig. 1083A

Heat Emission from Radiation Under Varying Pressure and Temperatures

The heat given off by the radiator is proportional to the difference in temperature between the room and the radiator. By varying the temperature of the radiator, the building temperature can be kept constant, and the heat given off by the radiator kept in proportion to the heat loss from the building. By operating the system at varying degrees of pressure or vacuum the temperature of

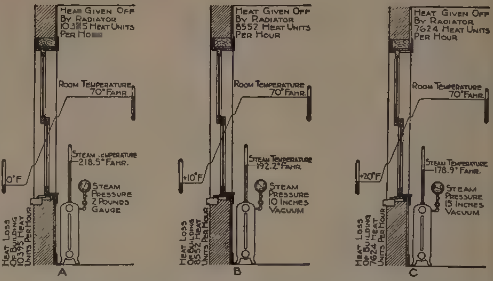

Heat Given Off By Radiator 10395 Heat Units Per Hour
Room Temperature 70° Fahr.
Steam Temperature 218.5° Fahr.
0°F
Steam Pressure 2 Pounds Gauge
Heat Loss Of Building 10395 Heat Units Per Hour
A
Heat Given Off By Radiator 8552 Heat Units Per Hour
Room Temperature 70° Fahr.
Steam Temperature 192.2° Fahr.
+10°F
Steam Pressure 10 Inches Vacuum
Heat Loss Of Building 8552 Heat Units Per Hour
B
Heat Given Off By Radiator 7624 Heat Units Per Hour
Room Temperature 70° Fahr.
Steam Temperature 178.9° Fahr.
+20°F
Steam Pressure 15 Inches Vacuum
Heat Loss Of Building 7624 Heat Units Per Hour
C

Fig. 1075A. Relation of Heat Loss and Heat Emission to Temperature Difference

This illustration shows how the room temperature is maintained uniformly under changing weather conditions, by varying the steam pressure so that the heat given off by the radiator equals the heat lost by the building.

the steam supplied to the radiators is varied to suit the changing weather conditions. This is the basic principle of the Dunham Differential Vacuum Heating System. (Fig. 1083A).

The heating profession has long realized that there is a large amount of heat wasted in mild weather because buildings are overheated. The cause of this waste in steam heated systems is that most all of them are operated on and limited in their operation to pressures above atmospheric, even in mild weather. Steam pressures ranging from a few ounces to 2 or 3 lb. afford but a small operating range of steam temperatures to meet changes in weather conditions. That is steam at a relatively constant pressure is usually supplied to the radiators regardless of what the outside weather may be.

The heat output of the radiators will therefore, be entirely too high in mild weather, when only a fraction of the radiation installed would actually be required to balance the heat loss of the building and maintain the desired temperature. The building temperature will increase above that desired, resulting in excessive heat loss from the building structure. This is generally termed overheating and represents a direct waste of fuel. Government weather reports show that extreme weather prevails during about 5 per cent of the average heating season when the system must be operated at full rating. This leaves 95 per

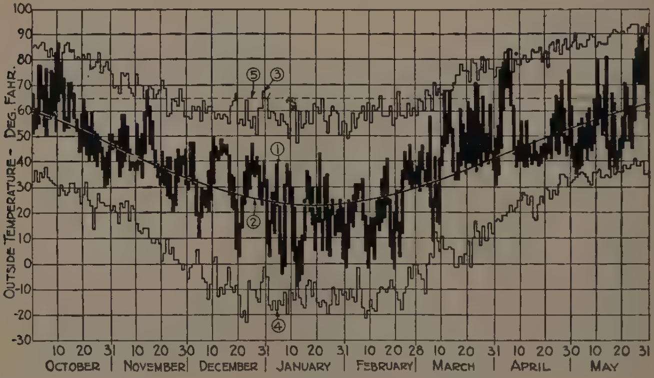


Fig. 1288. Average Temperature for Chicago Heating Season 1928-1929 = 40.2 deg.

(1) Maximum and minimum daily temperatures for 1928-29.
(2) Normal daily temperature from 54-year record.
(3) Hightest temperature on record.
(4) Lowest temperature on record.
(5) 65 deg. temperature base for degree-day calculation.

cent of the heating season when the heat output of the system must be reduced if uniform room temperature is to be maintained.

Daily weather reports show that the temperature rises and falls quite rapidly over the greater portions of the country. Temperature changes of 40 deg. per day occur each winter in the Chicago area, while daily changes of 20 deg. are but slightly higher than normal. To this variation in heat demand must be added the cooling effect of wind, if a true picture of the great fluctuations in heating requirements is wanted.

The graph, Fig. 1288, shows the official maximum and minimum temperatures at Chicago for each day of the heating season of 1928-29. It clearly shows the temperature fluctuations for that season and also the extreme limits of temperature recorded in the previous 54 years. During that year, there was a total of 131 hours when the temperature was 10 deg. or lower, with but 35 hours of this at zero or below. The heating season was but 0.4 deg. warmer than the average since the year 1900.

Fuel Saving of 25 Per Cent or More Compared with Ordinary Types of Steam Heating Systems

On buildings changed over to the Dunham Differential Vacuum System the performance records show actual fuel savings of 25 per cent or more compared with previous system.

The charts and illustrations on this and the following page tell this story in a nontechnical way.

Fig. 1066C, Steam Table Applied—This drawing gives a comparison of the properties of steam as used in the ordinary type heating system and the Dunham Differential Vacuum System.

The Ordinary System Has—

(1) Operating range zero to 5 lb. gauge pressure or higher.

(2) Temperature range 212 deg. fahr. to 227.1 deg. fahr.

(3) Volume per pound steam 26.79 to 20.42 cu. ft.

The Dunham Differential Vacuum System Has—

(1) Operating range 25 in. vacuum to 5 lb. gauge pressure or higher.

(2) Temperature range 133.22 deg. fahr. to 227.1 deg. fahr.

(3) Volume per pound steam 145 to 20.42 cu. ft.

By comparing the steam volumes and temperatures used in the two types of systems an index to the flexibility of each is obtained. The extreme flexibility of the Differential System eliminates overheating and reduces the heat lost through open windows.

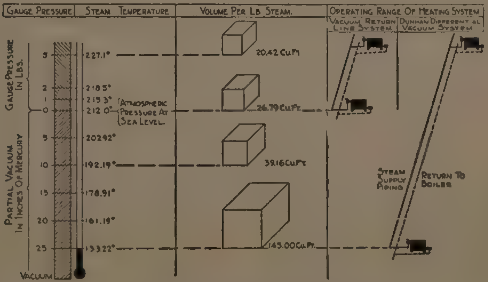


Fig. 1066C. The Steam Table Applied

Comparison of steam pressures, volumes and corresponding boiling points. Steam is produced at lower temperatures and circulated just as easily at 20 in. of vacuum as at 2 to 3 lb. gauge pressure.

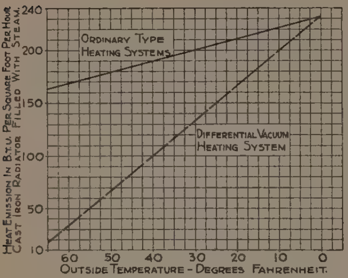


Fig. 1089A. Comparative Heat Emission from Radiators

This chart of heat emission from radiation is based on the room temperatures that would be obtained as shown by Fig. 1113A.

For example when the outside temperature is 30 deg. fahr. with the ordinary type heating system the room would be overheated to 90 deg. fahr. as noted from above graph. Using steam at zero gauge pressure, (212 deg. fahr.) the heat emission would be 200 B.t.u. per square foot per hour.

By controlling the pressure at which steam is supplied as in the Differential Heating System the heat emission is controlled in proporportion to the outside weather. Using the same example with 30 deg fahr. outside, the heat emission of a radiator on the Differential System would be 132 B.t.u. per square foot per hour keeping the room substantially at 70 deg. fahr. The effect of sun, wind and humidity on the building has not been considered in above graph. During cold and average weather the steam is furnished in sufficient quantity to completely fill the radiator at required degree vacuum. During mild weather the radiator may be only partly filled with steam under high vacuum.

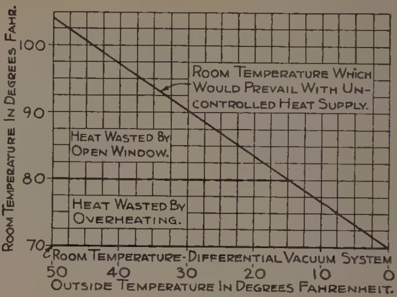


Fig. 1113A. Heat Saved by Controlling Heat Supply

This drawing shows the heat lost by overheating and wasted through open window in relation to the room temperature and the outside, disregarding the effect of sun, wind and humidity.

With the ordinary type heating system with uncontrolled heat supply the room or building would overheat in direct relation to the outside weather.

It was found by observation that occupants would allow room temperatures of approximately 80 deg. fahr. before windows would be opened, we have therefore termed the excess heat between 70 deg. and 80 deg. as, wasted through open windows. The diagonal line indicates the temperatures that would be attained if windows were kept closed, which is approximately same as would be lost if the windows were open.

General Description of Parts and Operation

The Dunham Differential Vacuum Heating System is a two-pipe system. Its general design and parts are very similar to the well known vacuum return line heating system of which this is a further development. The system may be controlled manually or automatically. (See Fig. 1247B).

Any Good Piping Job Is Sufficient—The piping is assembled so as to remain tight over a long period of years, just the same as is required for any other good job. The same quality of workmanship which is used to assemble hot water supply piping is easily sufficient with proper provision for expansion.

Control of Steam Supply

In smaller installations steam is supplied at the same vacuum (absolute pressure) at which it is to be used in the heating system by controlling the rate of heat generation at the boiler. On larger installations and on central station installations steam is furnished at a higher pressure than is required by the system and is reduced by means of pressure reducing valves to the desired vacuum or absolute pressure. These valves may either be manually or thermostatically controlled.

Regulating Plate at Each Radiator Assures Uniform Steam Distribution

By careful design and installation of a piping system, it is possible to get a distribution of steam at pressures which are fairly uniform throughout the piping. The use of a regulating plate in each radiator inlet valve assists steam distribution at all periods of the heating cycle. They interpose a small resistance to the flow of steam and create a reservoir condition within the supply piping.

During the heating-up period and while the radiators are filling with steam, the radiator traps are open to the return pipe and they remain open until steam reaches the trap when they close.

When the radiators are completely filled with steam and under normal operation, the regulating plates produce a semi-reservoir condition in the steam mains as compared with the condition when filling, by supplying an area for the flow of steam that is in proper relation to each size of radiator; if through some abnormal condition, the condensing rate of some radiator would be increased, the regulating plate will tend to prevent such a radiator from condensing an excessive amount of steam, notwithstanding the demand for it. This is of value in reducing heat loss through excess window ventilation.

Radiators of a heating system completely filled with steam under varying degrees of vacuum meet the average heat loss required during a season, but early autumn and late spring days with very much higher outside temperatures, require such a small heat output that even with a high vacuum, a radiator full of steam at a temperature corresponding to that pressure (vacuum) might under such conditions overheat the building if the system was not capable of further heat reduction. In the Dunham Differential System the quantity of steam supplied during such periods is reduced under a high vacuum, and the regulating plate controls its admission to each radiator so that each remains partly filled, balancing the heat input to the radiator with the heat loss of the building.

The Differential Thermostatic Radiator Trap on the outlet of each radiator is of importance, for by its use a positive differential can be maintained between the pressure (vacuum) in the radiator and the pressure (vacuum) in the return pipe, thus securing satisfactory heating.

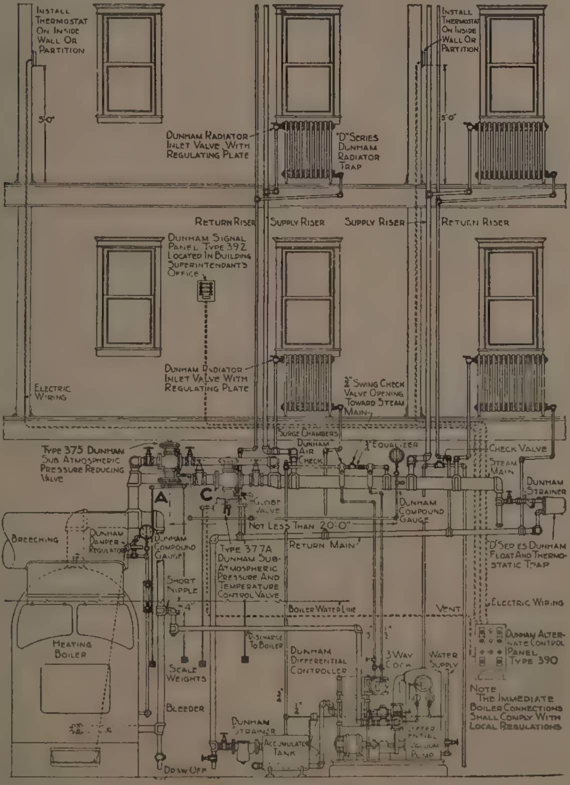

Install Thermostat On Inside Wall Or Partition
5'0"
Install Thermostat On Inside Wall Or Partition
5'0"
Dunham Radiator Inlet Valve With Regulating Plate
"D" Series Dunham Radiator Trap
Return Riser
Supply Riser
Supply Riser
Return Riser
Dunham Signal Panel Type 392 Located In Building Superintendent's Office
Dunham Radiator Inlet Valve With Regulating Plate
Electric Wiring
3/4" Swing Check Valve Opening Toward Steam Main
Surge Chambers
Dunham Air Check
3/4" Equalizer
Check Valve
Steam Main
Dunham Strainer
Type 375 Dunham Sub Atmospheric Pressure Reducing Valve
A
C
Globe Valve
Not Less Than 20'0"
Dunham Compound Gauge
Breeching
Dunham Damper Regulator
Dunham Compound Gauge
Return Main
"D" Series Dunham Float And Thermostatic Trap
Short Nipple
Type 377A Dunham Sub-Atmospheric Pressure And Temperature Control Valve
4"
Boiler Water Line
Vent
Electric Wiring
Heating Boiler
Discharge To Boiler
1/2"
1/2"
Dunham Alternate Control Panel Type 390
Scale Weights
Dunham Differential Controller
3 Way Cock
Water Supply
3/4"
1/2"
Note The Immediate Boiler Connections Shall Comply With Local Regulations
Bleeder
Dunham Strainer
Accumulator Tank
Differential Vacuum Pump
Draw Off

Fig. 1247B. Typical Layout of an Automatically Controlled System for Heating with Steam Below Atmospheric Pressure

Steam circulation is maintained by the Dunham Differential Vacuum Pump capable of producing a high vacuum. The pump is controlled by the Dunham Differential Controller which is an automatic electric switch actuated by the pressure difference in the radiation and return piping. The function of this controller is to automatically start or stop the pump so that a small but substantially constant pressure difference is maintained. This differential will furnish a head sufficient to cause steam flow toward the returns.

In operation, sub-atmospheric pressures (vacuum) are secured by retarding the admission of steam into the steam heating main until the desired vacuum is reached. If the rate of steam admission is too great, pressure on the main increases causing the valve to partially close, thus reducing the steam supply which permits the vacuum desired to again be obtained. Adjustment allows a greater or lesser vacuum to be maintained on the outlet side of the valve.

Method of Control

Automatic Control by Thermostats—Fig. 1247B illustrates a typical layout of a heating system which gives automatic control of the steam supply.

Thermostats located in key rooms control the operation of the larger of the two supply valves referred to on this page. This valve, located directly in the steam main is a motor operated valve. Its function is to admit additional steam to the heating system when the room thermostat calls for heat and to stop this flow when it is no longer required.

Room thermostats are electrically connected to the motor of this valve through a control panel, arranged so that the steam in the system may be either automatically controlled or manually controlled.

In buildings where varying wind conditions cause different demands for heat on the windward side, the use of several thermostats located on different sides of the building in separate key rooms has been the practice. The heating system may be under the control of any one of these thermostats.

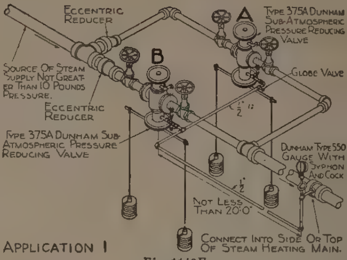

Eccentric Reducer
A
Type 375A Dunham Sub-Atmospheric Pressure Reducing Valve
B
Source Of Steam Supply Not Greater Than 10 Pounds Pressure.
Globe Valve
Eccentric Reducer
½"
Type 375A Dunham Sub-Atmospheric Pressure Reducing Valve
Dunham Type 550 Gauge With Syphon And Cock
½"
Not Less Than 20'0"
Application 1
Connect Into Side Or Top Of Steam Heating Main.

Fig. 1149E

Application 1 is a manually controlled Differential System using steam at not more than 10 lb. initial gauge pressure. For higher initial pressures see Application 3. Two Sub-atmospheric Pressure Reducing Valves are used as shown by Fig. 1149E. Valve "A" supplies steam in mild weather. The second valve, "B," supplies steam in cold weather. In extreme weather both valves may be used if necessary.

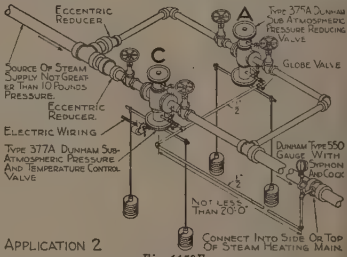

Eccentric Reducer
A
Type 375A Dunham Sub Atmospheric Pressure Reducing Valve
C
Source Of Steam Supply Not Greater Than 10 Pounds Pressure.
Globe Valve
Eccentric Reducer.
½"
Electric Wiring
Type 377A Dunham Sub-Atmospheric Pressure And Temperature Control Valve
Dunham Type 550 Gauge With Syphon And Cock
½"
Not Less Than 20'0"
Application 2
Connect Into Side Or Top Of Steam Heating Main.

Fig. 1150F

Application 2 is an automatically controlled system on which a Dunham Temperature Control Valve "C," operated from one or several thermostats is substituted for valve "B." Sub-atmospheric Pressure Reducing Valve "A" supplies steam in mild weather. As the weather becomes colder the Sub-atmospheric Pressure and Temperture Control Valve "C" supplies the necessary additional steam. The Thermostat must be placed in a typical room on the most exposed side of the building and at a point most remote from the source of steam supply measured along the steam piping. Its location should also represent the average building temperature and heat requirements.

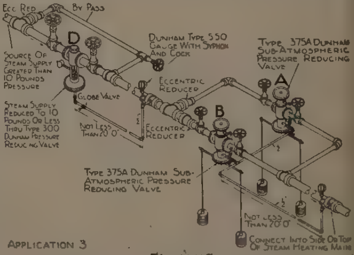

Ecc Red
By Pass
D
Dunham Type 550 Gauge With Syphon And Cock
Type 375A Dunham Sub-Atmospheric Pressure Reducing Valve
Source Of Steam Supply Greated Than 10 Pounds Pressure
Eccentric Reducer
A
Globe Valve
B
Steam Supply Reduced To 10 Pounds Or Less Thru Type 300 Dunham Pressure Reducing Valve
Not Less Than 20'0"
½"
Eccentric Reducer
Type 375A Dunham Sub-Atmospheric Pressure Reducing Valve
½"
Not Less Than 20'0"
Application 3
Connect Into Side Or Top Of Steam Heating Main

Fig. 1151G

Application 3 is a manually controlled system with initial steam pressure greater than 10 lb. gauge. The Pressure Reducing Valve "D" is used to reduce the steam pressure to 10 lb. or less before supplying the Sub-atmospheric Pressure Reducing Valves "A" and "B." If automatic temperature control is desired, valve "C" is substituted for valve "B." See Application 2.

Zoning—Individual Temperature Control for Sections of Buildings or Groups of Buildings

By "zoning" is meant the division of a heating system into smaller complete units for the purpose of separate control to secure lower operating costs.

Different parts of buildings require different quantities of heat at different times due to class of occupancy of various parts of building, sun and wind effect on the different sides, and buoyancy of the heated air as in very tall buildings. Therefore, all large buildings should be "zoned" to secure maximum conservation of steam and correct heating of all sections.

The Dunham Zone Temperature Control in conjunction with the Dunham Differential Vacuum Heating System, see Fig. 1247B, Page 789, provides remote electrical control of the steam supply as required by each zone.

Each zone operates from its own thermostat located at a suitable control point or "key-room." Furthermore each zone must be served by its own Differential Pump where the building is divided into two or more independent zones.

A building may be divided into any number of zones but an average size building could conveniently be divided into two zones—one set of piping caring for the west and south sides, the other set for the north and east sides. Usually in ordinary heating, Duplex Pumps are specified. This, in the Differential System will allow a pump on each zone. The same theory is applied to groups of buildings—each independently controlled from the boiler room.

A building is divided into the necessary zones by having each zone supplied from its own steam main. The supply of steam from each main is controlled by a Dunham Type 377A (electrically operated) Sub-atmospheric Pressure and Temperature Control Valve. One or more thermostats are located at the proper points in the zone and set to a predetermined degree.

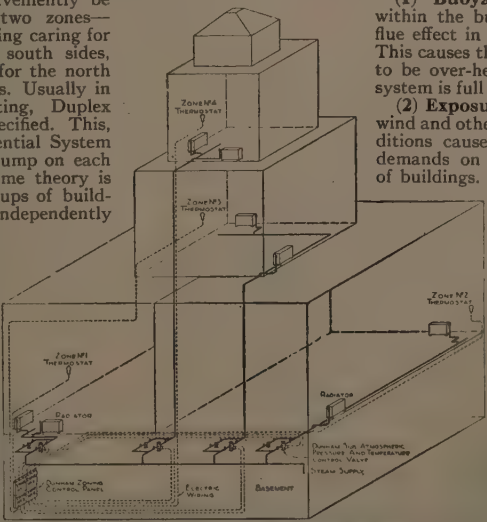


Fig. 1245. Schematic Illustration of a System Equipped with Four Zones (or Sections), with Each Zone Controlled Independently of the Others. This Drawing Does Not Give Actual Piping Details, the Purpose Being to Illustrate the Control System Only—and Not the Heating System

Automatic Remote Control—When the room thermostat of any zone calls for heat, the sub-atmospheric control valve for that zone opens automatically, allowing more steam to flow into it, producing the required rate of heat transfer from the radiation. When the proper heat is obtained this additional steam supply is stopped.

Manual Remote Control—The control valves for each section being electrically operated can also be remotely controlled independently of the thermostats. A Dunham Zone Control Panel in the boiler room shows the operating engineer at a glance the temperature conditions in the various zones and he can, by simply throwing a switch, accelerate or decelerate the rate of steam flow to the particular zone.

Controlling Factors in Designing a Zoning System

(1) **Buoyancy** — Rising within the building due to flue effect in tall buildings. This causes the upper floors to be over-heated after the system is full of steam.

(2) **Exposure**—Sunshine, wind and other weather conditions cause variable heat demands on different sides of buildings.

(3) **Type of Occupancy**—Sections of the same building may require different degrees of heat due to their particular uses, such as storage, manufacturing, office space, etc., or periods of occupancy.

No particular rule can be given for the zoning of a building, each is an individual problem and should be studied carefully.

The "D" series Dunham Differential Vacuum System is for the heating of office buildings, hotels, apartment houses, schools and groups of buildings, etc., of more than 3,000 sq. ft. of equivalent direct radiation.

The boiler serves as a heat storage from which steam is supplied according to the demand of the Sub-Atmospheric Pressure Reducing Valve or Temperature Control Valve. The manually controlled system uses two sub-atmospheric pressure reducing valves. The small valve "A" supplies steam in mild weather, valve "B" in cold weather. In extreme weather both valves may be used, if necessary. By shifting the weights of the valve in use, the steam pressure (vacuum) is controlled in accordance with outside weather conditions.

In the automatically controlled system a Temperature Control Valve "C" is substituted for valve "B."

The Dunham Differential Controller starts and stops the pump maintaining, under all steam supply conditions, a greater vacuum in the returns than in the radiators.

This assures complete circulation at all times. In severe weather when steam pressure above atmospheric is required (to maintain the room temperature) the Differential Controller automatically stops the pump until pressure conditions in the system make its operation necessary.

The DUNHAM
Difr-enshal-Vacm
Heating System
A FIXED DIFFERENTIAL IN PRESSURE
A VARIABLE [illegible] VACUUM

The Dunham Differential Vacuum Heating System and individual parts of the apparatus used in that system are fully protected by United States Patents Nos. 1,644,114 and 1,706,401, and Canadian Patents Nos. 282,193, 282,194 and 282,195. Additional patents in the United States, Canada and foreign countries are now pending.

Central Station Heating

The Dunham Differential Vacuum Heating System is especially adapted to Central Station Steam Supply. It offers great economy of steam consumption and very low condensate temperatures. Another advantage is complete circulation even though the pressure carried on the distributing mains from the boiler plant is low. This system therefore is ideal both from the standpoint of the Central Station Company and the Consumer.

Exhaust Steam

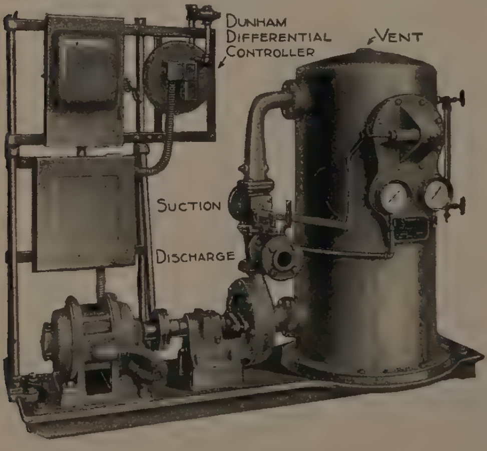
Exhaust steam may be circulated under vacuum, thus saving steam formerly wasted. The application of this system reduces the back pressure to a vacuum and greater power output will be obtained.

In installations where high steam pressures and temperatures are necessary for process work the building heating system can be operated more economically by applying the differential principle to it. By reducing the high steam pressure through reducing valves the heat input may be controlled and the overall economy of the plant improved.

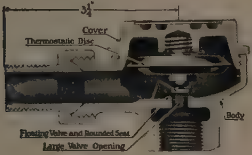
Dunham Differential Vacuum Pump, "D" Series

The Dunham Differential Vacuum Pump operates on the Jet Exhauster principle. The Dunham Exhauster is a special design and has great air and vapor handling capacity. Under high pressures water is supplied from the receiving tank to the exhauster by a motor driven enclosed impeller type centrifugal pump of high efficiency.

The pump exhausts air and water from return piping under very high vacuums and discharges condensate to the boiler. It is a completely assembled compact unit ready for piping and wiring connections.



Dunham Thermostatic Radiator Trap

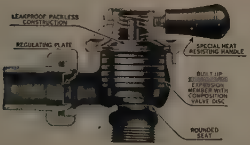


Sectional View of Trap.

Sectional view of Dunham Differential Thermostatic Radiator Trap, sizes, styles and specifications, see Dunham Hand Book.

All traps used in connection with the Dunham Differential Vacuum Heating System are known as "D" Series. They function uniformly over a wide range of pressures and temperatures from 25 in. of vacuum to 25 lb. gauge pressure.

Dunham Packless Radiator Valve


LEAKPROOF PACKLESS CONSTRUCTION
REGULATING PLATE
SPECIAL HEAT RESISTING HANDLE
BUILT UP EXPANSION MEMBER WITH COMPOSITION VALVE DISC
ROUNDED SEAT

Sectional View, Type 105, Dunham Packless Radiator Valve with Regulating Plate

For sizes, styles and specifications, see Dunham Hand Book.

Dunham Packless Radiator Valves with Regulating Plate must be used on all radiators to secure proper balance. Either Type 105 (lever handle) or Type 145 (wheel handle) may be used.

The valve is made packless by means of the bellows construction. The plate orifice is calibrated to the number of feet of radiation in each radiator.

Dunham Regulating Plate, Type 192

Types of Control

The system of control is arranged so that:

A single valve may be controlled by a single thermostat.

A single valve may be controlled by several thermostats.

Several valves may be controlled each by its own thermostat.

Several valves may be controlled each by several thermostats.

The control panel in each case is centralized in the boiler room.

Where heating systems are divided into complete zones (or for systems where only one thermostat is intended to control one valve) Control Panel Type 391 is used.

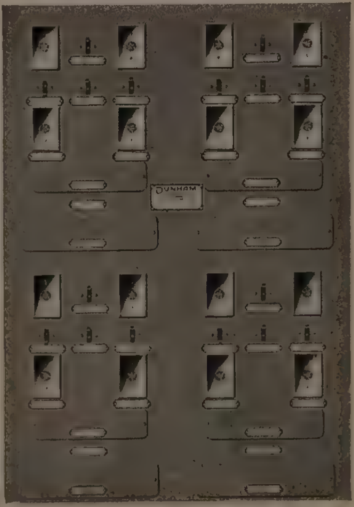
Either control provides the following advantages:

It centralizes control of the entire steam supply.

It permits either automatic or manual operation.

It gives the attendant the information he desires regarding temperature conditions prevailing in various parts of the building, in addition to informing him whether or not the valve is admitting steam to the system.

Each panel is provided with a red and a green light for each thermostat and valve. Switches are provided for transferring the



Type 391

system from automatic control to manual operation. Each thermostat has a switch to permit its being disconnected from the control.

The line switch is also provided on the control panel to disconnect the entire control system from the electric supply line.

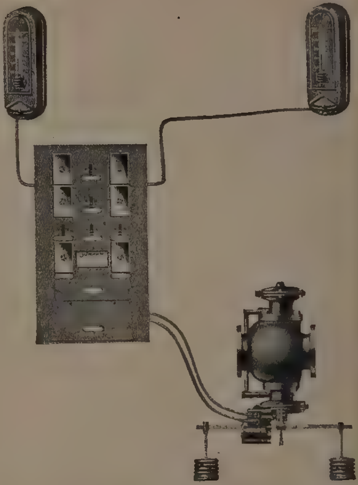
Alternate Control Panel—The Alternate Control Panel, Type 390, enables the engineer to know temperature conditions in the building and to regulate the temperature in various parts of the structure. The application is similar to "Zoning" (described on preceding page) and is recommended for systems that cannot be readily divided into separate zones. The piping arrangement may not permit this ideal, complete division, but the medium size building and the change-over installation may have the benefit of control through this Control Panel in conjunction with Type 377A Valve. It is also connected to two or more thermostats, located at different points of the building (to obtain heat control of the coolest part, depending upon wind and sun effect upon the building). The panel is equipped with lights which indicate to the engineer the heat conditions in the building—a green light is shown when the thermostat indicates proper temperature and a red light flashes when the thermostat is below this temperature. Any thermostat calling for heat automatically takes charge of the heat supply. The panel is also provided with switches for obtaining manual control.

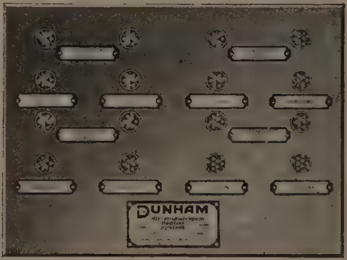
When desired a Signal Panel can be provided to be located in the building superintendent's office enabling him to observe temperature conditions and operation of the temperature controlled valves in the various zones.

This panel will indicate simulatneously with the panel in the boiler room the range of temperature existing in the building and the position of the temperature controlled valves.

The "DH" Series—is for small installations with gravity returns to boiler having a total equivalent direct radiation load of not more than 3,000 sq. ft. (excluding piping). It is entirely automatic in operation.

This system will heat properly any residence or small building without the usual fuel and heat waste caused by overheating and resultant excessive window ventilation. It furnishes steam to the radiators at sub-atmospheric pressures with correspondingly low radiator temperatures, causing a uniform, mild and healthful heat to be distributed throughout the building. This gives the occupants a comfort heretofore unknown, with healthier living conditions.





Type 392. Signal Panel for Superintendent's Office

"DH" Series Dunham Differential Pump

Heating Specifications

"D" Series, Dunham Differential Vacuum Heating System

1. GENERAL CONDITIONS.—The general conditions governing this work shall be those established as standard by the American Institute of Architects which shall apply hereto.

2. CONSTRUCTION AND MATERIAL.—The heating apparatus, proposed herewith includes the furnishing, delivery and erection on the premises of all necessary material and labor, which shall be first class in all particulars, and in accordance with the specifications and plans.

3. INSPECTION.—The Heating Contractor must at all times allow the C. A. Dunham Company's Representative to come on the job for the purpose of inspection and must lend any assistance necessary to expedite and complete the work. Any instructions given by the C. A. Dunham Company's Representative and confirmed in writing regarding changes to make system conform to plans or specifications and details shall be considered a part of this specification.

4. BOILER.—The steam boiler shall be a.......................... with guaranteed rating for..........................sq. ft. of radiation installed upon suitable foundation, and equipped with all necessary connections and trimmings, including a safety valve set to blow at 10 lb. pressure, a Dunham Compound Gauge 15 lb. x 30 in. vacuum and a 7-in. Dunham Damper Regulator. (Omit Regulator on gas fired and automatic oil fired installations).

5. SMOKE PIPE.—Connect boiler to chimney with suitable black iron smoke pipe gauge.......................... Size to be as recommended by Boiler Manufacturer. Smoke pipe must be provided with hand stop damper. (Omit stop damper on gas fired installation).

6. PRESSURE AND TEMPERATURE CONTROL.—On all systems not equipped with full automatic control of fire, install Dunham Sub-Atmospheric Control Valves of size shown on plans, with necessary gate valves. Install Dunham 15 lb. x 30 in. compound gauges where directed. If Thermostats and Dunham Control Panels are to be used, Heating Contractor shall furnish, install and wire these, all in accordance with manufacturer's details and instructions.

7. PIPE AND FITTINGS.—Furnish and erect with tight connections all necessary piping of sizes shown on plans and run as indicated, supported and properly graded to insure free and noiseless circulation. Use fittings of cast iron of standard quality. The ends of all pipes shall be reamed or filed. Proper provision must be made for expansion. Use graphite and oil for making up all pipe joints applied to male thread only. Provide for expansion of mains and risers by loop type expansion joints and swing connections in mains wherever possible. In other cases provide approved all-metal packless expansion joints. Piping to be properly anchored.

8. All steam tappings in boiler shall be connected full size of tapping into a steam header which shall be dripped to the return header through a bleeder. All spring pieces to steam and return mains shall be taken off the top of mains at 45 deg. On down-feed systems, take the spring pieces from the bottom of steam main at 90 deg.

9. The end of each steam main and each drip point shall be drained, through a gate valve, Dunham Strainer, and "D" Series Dunham Trap as indicated on plans.

No lift connections shall be used at drip points.

10. Grade steam mains, return mains and drip mains ½ in. in 10 ft. All steam supply branches such as spring pieces, offsets in steam risers and runouts to radiators shall in each case be installed one size larger than the vertical pipes to which they connect and shall be given as much grade as possible ½ in. per ft. is preferable.

11. Return mains shall be connected together into the accumulator tank of Dunham Differential Vacuum Pump as shown in detail furnished by manufacturer. Lift connections must not be used except between pump and accumulator tank.

12. Risers are to be run concealed or in the open as directed by the architect. Each down-feed steam riser must be dripped into the return through a "D" Series Dunham Trap. Install traps as instructed by manufacturer. All concealed piping must be tested and made tight at 15 lb. water pressure before being concealed and covered.

13. All union connections, flanges, packing nuts on gate and globe valves and on gauge glass of boiler must be drawn up tight so as to prevent air leaking into system when under a high vacuum. This work must be performed after system is completed and while it is working with a vacuum in both steam and return lines.

14. FLOOR PLATES, SLEEVES—Furnish approved floor and ceiling plates, protecting sleeves on all pipes passing through floors or finished partitions.

15. DIFFERENTIAL VACUUM PUMP.—Furnish and install one or several (as indicated on plans) Dunham Differential Vacuum Pumps of "D" series size.......................... having a differential rating of..........................sq. ft. of equivalent direct radiation. The pump (or pumps) shall be installed, connected and wired in accordance with manufacturer's instructions and local regulations.

15A. DOMESTIC HOT WATER AND BLAST HEATER.—Condensation from this equipment shall be returned to boiler by other means than Dunham Differential Vacuum Pump.

16. CHECK VALVES.—Check valves shall be horizontal swing type with brass disc, best grade obtainable. They shall be installed where called for by the plans, and in accordance with accompanying details. They shall be tested for tightness.

17. RADIATION.—Furnish and install radiation as shown on the plans. There shall be..........................sq. ft. of direct radiation of approved make. All radiators must be provided with top inlet tapping. Furnish ½-in. eccentric bushing in the return tapping. All air valve tappings shall be plugged.

18. RADIATOR TRAPS AND VALVES.—Each radiator shall be provided with a Dunham "D" Series Radiator Trap of suitable capacity. A Dunham Packless Radiator Valve with Dunham Regulating Plate shall be installed at inlet connection according to manufacturer's instructions.

19. PAINTING.—All exposed piping in finished rooms shall be given a priming coat of flat paint and thereafter painted or enameled as directed by architect. Radiators shall be painted as directed by architect. All pipe joints and all uncovered piping in basement, front and other exposed parts of boiler shall be painted one coat of black asphaltum when the system is hot and under a vacuum. The finishing coat of paint must be applied when the entire system is under vacuum, so that paint will fill up small leaks.

20. COVERING.—Cover all steam mains and spring pieces with four-ply, 1 in. thick asbestos sectional covering and fittings with asbestos cement. Cover all steam and return risers and other piping run concealed in outside walls with two-ply, ½ in. thick asbestos sectional covering. Cover boiler as specified by boiler manufacturer.

21. FINISHING UP.—After system has been in operation two weeks, thoroughly blow down and clean out system as follows:

Remove the safety valve and connect a temporary blow-off pipe to the safety valve tapping, extending it outside or to some suitable drain. Shut off all radiator valves or valves in main. Fill the boiler with water to top of gauge glass. Build a very hot fire and blow steam and water out through the safety valve tapping and pipe connected thereto. Fire hard with not more than 10 lb. pressure on the boiler. Supply cold water constantly in at bottom of the boiler. Continue this for six hours. At the end of the period, close the water feed valve, draw the fire quickly, open blow-off at bottom of boiler and entirely drain the boiler, replace the safety valve. Fill the boiler slowly after it becomes cold.

Remove the cover of each trap and wipe off grease and dirt accumulation. Replace trap cover tightly on body.

22. TEST.—The System when finished and cleaned shall be tested for tightness as directed by C. A. Dunham Company's Representative. Contractor shall furnish labor and material for performing test.

23. GUARANTEE.—The Heating Contractor shall guarantee the apparatus installed to circulate steam thoroughly through every radiator without noise, with a vacuum of 15 in. in steam main. If the apparatus shall fail to accomplish this guarantee by reason of any defect developing within the period of one full heating season and that defect is due to faulty material or poor workmanship, the Heating Contractor shall remedy such defect at his own cost within reasonable time after notice thereof.

24. FINALLY.—Nothing herein contained can be construed to relieve the Heating Contractor from making good and perfect work in all usual details of construction, and he will be held responsible to provide and furnish necessary material and to perform all necessary labor and to bear all expenses incidental to the satisfactory completion of the work.

Heating Specifications

"DH" Series, Dunham Differential Vacuum Heating System

1. GENERAL CONDITIONS.—The general conditions governing this work shall be those established as standard by the American Institute of Architects.

2. CONSTRUCTION AND MATERIAL.—The heating apparatus proposed includes the furnishing, delivery, and erection on the premises of all necessary material and labor, which shall be first class in all particulars and in accordance with specifications and plans.

3. INSPECTION.—The Heating Contractor must at all times allow the C. A. Dunham Company's Representative to come on the job for the purpose of inspection and must lend any assistance necessary to expedite and complete the work. Any instructions given by the C. A. Dunham Company's Representative and confirmed in writing regarding changes to make system conform to plans or specifications and details shall be considered a part of this specification.

4. BOILER.—The steam boiler shall be a.................... with guaranteed rating for....................sq. ft. of direct radiation installed upon suitable foundation and in accordance with manufacturer's setting instructions. It shall be equipped with all necessary connections and trimmings, including a safety valve set to blow at 10 lb. pressure, a Dunham Compound Gauge 15 lb. x 30-in. vacuum and a 10-in. Dunham Damper Regulator. (Omit Regulator on gas fired and automatic oil fired installations).

5. SMOKE PIPE.—Connect boiler to chimney with suitable iron smoke pipe same size as boiler smoke outlet. Smoke pipe must be provided with approved Dunham Check Damper and hand stop damper between check damper and boiler. (Omit Dunham Check Damper on automatic oil fired installations). (Omit check damper and hand stop damper on gas fired installations).

6. PIPE AND FITTINGS.—Furnish and erect with tight connections all necessary piping of sizes shown on plans and run as indicated, supported and properly graded to insure free and noiseless circulation. Use fittings of cast iron of standard quality. The ends of all pipes shall be reamed or filed. Proper provision must be made for expansion. Use graphite and oil for making up all pipe joints applied to male thread only.

7. All steam tappings in boiler shall be connected full size of tapping into a steam header which shall be dripped to the return header through a bleeder. All spring pieces to steam and return mains shall be taken off the top of mains at 45 deg.

8. The end of each steam main shall be dripped as indicated on the plans by means of a drip line to boiler, properly vented through Dunham "D1" Trap in accord with details furnished by manufacturer.

9. Grade steam mains ½ in. in 10 ft. Grade return mains and drip mains 1 in. in 10 ft. All steam supply branches such as spring pieces, offsets in steam risers and runouts to radiators shall in each case be installed one size larger than the vertical pipes to which they connect and shall be given as much grade as possible. ½ in. per ft. is preferable.

10. Return mains shall be connected to the Dunham Differential Vacuum Pump as shown in detail furnished by manufacturer.

11. Risers are to be run concealed or in the open as directed by the architect. All concealed piping must be tested and made tight at 15-lb. water pressure before being concealed and covered

12. All union connections, flanges, packing nuts on gate and globe valves and on gauge glass of boiler must be drawn up tight so as to prevent air leaking into system when under a high vacuum. This work must be performed after system is completed and while it is working with a vacuum in both steam and return lines.

13. FLOOR PLATES, SLEEVES.—Furnish approved floor and ceiling plates and protecting sleeves on all pipes passing through floors or finished partitions.

14. THERMOSTATIC CONTROL.—Contractor shall furnish and install where shown on plans a Series 10 Minneapolis Honeywell Thermostat according to manufacturer's instruction. (If this thermostat is being supplied with oil or gas burner under another contract, then the Heating Contractor shall connect Differential Vacuum Pump to the Thermostatic Control).

15. DIFFERENTIAL VACUUM PUMP AND AIR ELIMINATOR.—Furnish and install a "DH" Series Dunham Differential Vacuum Pump. The pump shall be installed and connected in accordance with manufacturer's instructions and details. The necessary electric wiring between pump and differential control, shall be connected to the thermostatic equipment in accordance with manufacturer's instructions and in conformity with all local regulations.

Furnish and install on return main in accordance with manufacturer's instructions a Dunham Air Eliminator. Install a Dunham Air Check on vent opening of eliminator.

16. CHECK VALVES.—Check valves shall be horizontal swing type with brass disc, best grade obtainable. They shall be installed where called for by the plans and in accordance with accompanying details. They shall be tested for tightness.

17. RADIATION.—Furnish and install radiation as shown on the plans. There shall be....................sq. ft. of direct radiation of approved make. All radiators must be provided with top inlet tapping. Furnish eccentric bushing in the return tapping. All air valve tappings shall be plugged.

18. RADIATOR TRAPS AND VALVES.—Each radiator shall be provided with a Dunham "D" Series Radiator Trap of suitable capacity. A Dunham Packless Radiator Valve with Dunham Regulating Plate shall be installed at inlet connection according to manufacturer's instructions.

19. PAINTING.—All exposed piping in finished rooms shall be given a priming coat of flat paint and thereafter painted or enameled as directed by architect. Radiators shall be painted as directed by architect. All pipe joints and all uncovered piping in basement, front and other exposed parts of boiler shall be painted one coat of black asphaltum when the system is hot and under a vacuum. The finishing coat of paint must be applied when the entire system is under vacuum, so that the paint will fill up small leaks.

20. COVERING.—Cover all steam mains and spring pieces with four-ply, 1-in. thick asbestos sectional covering and fittings with asbestos cement. Cover all steam and return risers and other piping run concealed in outside walls with two-ply, ½-in. thick asbestos sectional covering. Cover boiler as specified by boiler manufacturer.

21. FINISHING UP.—After system has been in operation two weeks, thoroughly blow down and clean out system as follows:

Remove the safety valve and connect a temporary blow-off pipe to the safety valve tapping, extending it outside or to some suitable drain. Shut off all radiator valves or valves in main. Fill the boiler with water to top of gauge glass. Build a very hot fire and blow steam and water out through the safety valve tapping and pipe connected thereto. Fire hard with not more than 10-lb. pressure on boiler. Supply cold water constantly in at bottom of the boiler. Continue this for six hours. At the end of the period, close the water feed valve, draw the fire quickly, open blow-off at bottom of boiler and entirely drain the boiler, replace the safety valve. Fill the boiler slowly after it becomes cold.

Remove the cover of each trap and wipe off grease and dirt accumulations. Replace trap cover tightly on body.

22. TEST.—The system when finished and cleaned shall be tested for tightness by filling it with water to its very top. The water shall be left standing in the system at least four hours after all leaks have been made tight, when final test and inspection in presence of Dunham Representative shall be made for leaks. The contractor must take precaution to guard against damage from freezing during test.

23. GUARANTEE.—The Heating Contractor shall guarantee the apparatus installed to circulate steam thoroughly through every radiator without noise, with a vacuum of 15 in. in steam main. If the apparatus shall fail to accomplish this guarantee by reason of any defect developing within the period of one full heating season and that defect is due to faulty material or poor workmanship, the Heating Contractor shall remedy such defect at his own cost within reasonable time after notice thereof.

24. FINALLY.—Nothing herein contained can be construed to relieve the Heating Contractor from making good and perfect work in all usual details of construction, and he will be held responsible to provide and furnish necessary material and to perform all necessary labor and to bear all expenses incidental to the satisfactory completion of the work.

TRADE-MARK

Julian d'Este Company

6 Spice Street, Charlestown Dist.
Boston, Mass.

Manufacturers of Curtis Engineering Specialties
Pressure Regulators and Steam Traps

Type E Regulator

Sizes ½ in. to 8 in. inclusive.

For water service.

Saves wear on plumbing fixtures.

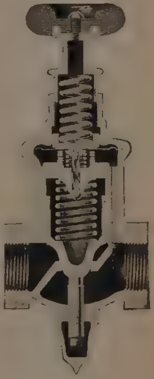
Eliminates water hammer.

Full sized seat area.

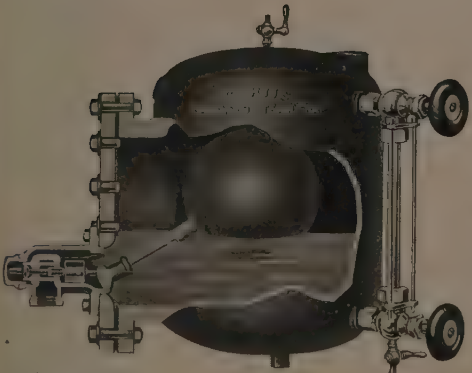
Sizes ½ in. to 4 in. inclusive.

A compact, self-contained valve, piston actuated, for steam or air service.

Ideal for high and intermediate pressures.



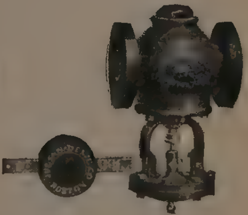
Type D Regulator



CURTIS BALANCED STEAM TRAP

A quality product for large volume of condensate. Large sized seat area. Continuous flow in operation.

Sizes ½ in. to 4 in., inclusive.



Type K Regulator

Sizes ½ in. to 10 in.

Also furnished in increased outlet sizes up to 8 x 16 in.

Ideal for steam heating or low pressure requirements demanding a large volume of steam.

William S. Haines & Company

12th and Buttonwood Sts., **Philadelphia, Pa.**

Manufacturers of Equipment for Vapor and Vacuum Heating Systems

Haines Vento Thermostatic Trap.

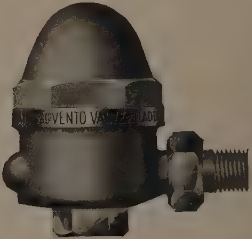
Haines Medium Pressure Thermostatic Trap.

Haines High Pressure Thermostatic Trap.

Haines Float and Thermostatic Blast Trap.

Haines Vent Trap.

Haines Modulating Valve.



HAINES traps pass all of the air and the water of condensation without permitting the escape of steam.

The HAINES Vento Trap is operated by a spring tempered rust resisting steel alloy bronze coated thermostatic bourdon tube, (similar to and as accurate as the bourdon tube in all pressure gauges) in which a volatile liquid is hermetically sealed. In this thermostat, the strength of the steel tube, the bronze coating eliminating any possible chance of the thermostat becoming inoperative through rust, or chemicals found in the water of condensation, readily enables us to give a five year guarantee on the HAINES Vento Radiator Traps when installed in connection with a vapor, vapor vacuum, vacuum or differential system of steam heating. The thermostatic member is mounted outboard the valve seat, closing the valve piece against the flow of steam. A variation of 1 deg. fahr. is sufficient to open or close the valve. Due to the horizontal seat and the placing of the thermostat in the return line HAINES Vento Traps do not become ineffective from scale, or other foreign matter and they cannot freeze.

HAINES thermostatic traps are made in sizes from ½ to 1½ in. Every trap is factory tested and adjusted before shipment. They are suitable for pressures from below atmosphere to 100 lb. per sq. in.

HAINES modulating valves never need repacking. They seat tightly and open on less than a full turn of the lever or wheel handle.

Made in sizes from ½ to 2 in. in angle, globe, or corner pattern.

HAINES VENTO TRAPS

No. of Trap	Center to Inlet	Center to Outlet	Capacity Sq. Ft.
1	2 7/8"	1 1/16"	125
2	3 1/4"	1 5/16"	200
2E	3 3/8"	1 5/16"	250
3	3 5/8"	1 11/16"	400
3E	3 7/8"	1 11/16"	500

HAINES MODULATING VALVES

Size of Valve	Center to Inlet	Center to Outlet
1/2"	1 7/16"	2 1/2"
3/4"	1 1/2"	2 5/8"
1"	1 11/32"	3"
1 1/4"	1 15/16"	3 5/8"
1 1/2"	2 1/16"	4 1/4"
2"	2 5/8"	4 15/16"

Hoffman Specialty Co., Inc.

Waterbury, Conn.

Sales Representatives in Principal Cities

HOFFMAN VALVES and CONTROLLED HEAT EQUIPMENT

HOFFMAN VENTING VALVES

In the Hoffman line there is a specially designed venting valve for every type of steam heating system. The basic principle used in the design of all Hoffman venting valves is that of an all-metal thermostatic member, with one or more flexible diaphragms, containing a volatile or heat sensitive fluid which causes valve action upon slight temperature changes.

Hoffman valves have a wide pressure range in which they operate with the same degree of accuracy, for the internal fluid pressure in the thermostatic member maintains a constant relationship with the external steam pressures throughout the whole range of pressure for which each valve is intended.

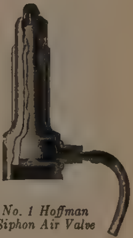
Hoffman valves are automatic, non-adjustable and (except Nos. 20 and 21) are guaranteed to properly function for a period of five years from date of installation when installed and operated under normal conditions for which designed.

VENTING VALVES FOR ONE-PIPE SYSTEMS

ALL METAL—NON-ADJUSTABLE—THERMOSTATIC

The No. 1 Hoffman Siphon Air Valve is designed for systems of the one-pipe gravity type, to vent all air from radiators without loss of steam. After contact of water with the valve the siphon drains all water from the valve and venting occurs without the slightest "spit" even if the radiator is under pressure.

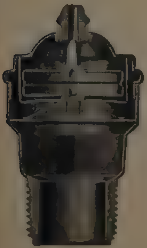
Radiator connection, ⅛ in. Maximum guaranteed operating pressure, 10 lb. Furnished with special short siphons for narrow pattern radiators.



No. 1 Hoffman Siphon Air Valve

The No. 4 is used in venting mains, risers, vento stacks, coils, etc. All air is freely vented through a ⅛ in. vent port without steam loss, but valve does not close against water.

Standard connection, ¾ in., can also be supplied with ¼ in. connection. Maximum guaranteed operating pressure, 10 lb.

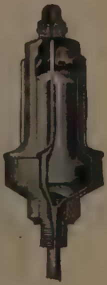


No. 4

The No. 5 is particularly adapted for use in venting: Ends of steam or dry return mains; Indirect radiators; Blast or "Vento" stacks; Hot-water generators; Dryers and drums, etc.

The basic principle is the same as the No. 1 Valve, having separate channels for air and water which are only found in Hoffman Valves.

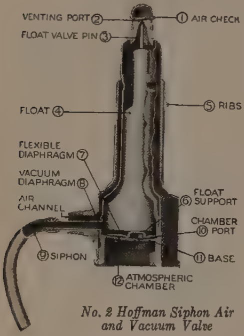
Pipe connection, ⅜ in.; vent port for less than 3 lb. is $\frac{3}{16}$ in.; for 3 lb. and over is $\frac{1}{16}$ in. Unless otherwise ordered, will be shipped with $\frac{1}{16}$ in. port. Maximum guaranteed operating pressure, 10 lb.



No. 5

Write for Descriptive Circular—
The Watchman of the Coal Pile

VENTING VALVES FOR ONE-PIPE VACUUM SYSTEMS



No. 2 Hoffman Siphon Air and Vacuum Valve

In construction, the No. 2 Valve is similar to the No. 1 with the addition of a vacuum diaphragm in the base and an air check over vent port.

Upon steam contact, float diaphragm (7) expands, closing port (2). When pressure goes below atmosphere vacuum diaphragm (8) follows up contracting float diaphragm, maintaining port closed against air intake.

Air check (1) functions only in the case of a half-hot radiator when float diaphragm (7) is not expanded by steam contact. With a cessation of steam generation, air check holds port closed against air intake until pressure goes below atmosphere and when a 1 in. vacuum forms diaphragm (8) expands, closing port, relieving air check of any further function.

The superiority of the diaphragm controlled port compared with valves having air check only is indicated by the fact that the total pressure exerted in holding vent port closed is approximately 20 times greater than that exerted in maintaining an air check closed.

This greater pressure, exerted by the vacuum diaphragm holds the valve pin more tightly against its seat and also aids in crushing or pushing away dirt particles which might be caught between the valve pin and its seat.

Radiator Connection ⅛ in. Maximum guaranteed operating pressure 10 lb. Furnished with special short siphons for narrow pattern radiators.

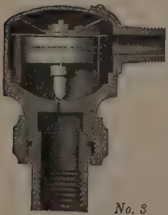
No. 6

The No. 6 Float Air and Vacuum Valve is similar in design and application to the No. 5 with the additional feature of the Air Check or Vacuum starter above vent port and vacuum diaphragm in base. Used for venting ends of mains, vento stacks, etc., where water is liable to be present.

Pipe connection, ⅜ in.; vent port for less than 3 lb. is 3/16 in.; for 3 lb. and over is 1/16 in. Unless otherwise ordered, will be shipped with 1/16 in. port. Maximum guaranteed operating pressure, 10 lb.

The No. 16 Air and Vacuum Valve is used for venting ends of steam and dry return mains. Valve is 3⅜ in. high overall, permitting installation in lines close to ceiling. It has the special Hoffman feature, the combined air check and vacuum diaphragm for preventing return of air to system. Pipe connection, ¾ in. Vent port 1/16 in. dia. Maximum operating pressure, 10 lb.

No. 16



No. 3

The No. 3 Hoffman Air Line Valve is specially designed for Air Line, or as they are frequently termed "Paul" Systems. It is sensitive in action and closes the instant steam fills the radiator.

Radiator connection, ⅛ in.; Air Line connection, ¼ in. Maximum guaranteed operating pressure, 10 lb.

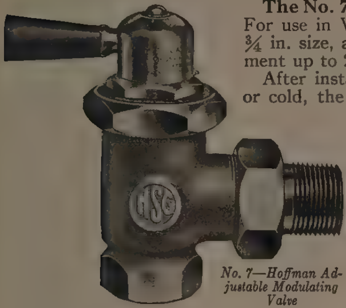
THE HOFFMAN VALVE LOCK

Prevents theft of No. 1 and No. 2 valves in public buildings, etc. No extra tapping is required as lock is easily applied when valve is inserted in radiator. By using set screws, valve is locked in position and can only be removed by a special key.

Hoffman Valve Lock

Write for Descriptive Circular—Locking the Door Against the Heat Thief

HOFFMAN "CONTROLLED HEAT" EQUIPMENT

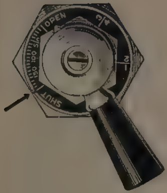


No. 7—Hoffman Adjustable Modulating Valve

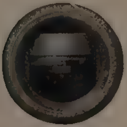
The No. 7 Hoffman Adjustable Modulating Valve—For use in Vapor or Vapor Vacuum systems, is made in ¾ in. size, angle pattern only, having a range of adjustment up to 200 sq. ft. of direct cast-iron radiation.

After installation, whether the system is in operation or cold, the port of each valve is adjusted for the size of the radiator to which it is attached. Adjustment is simple; loosen a locknut; turn valve handle until proper number of graduations are visible on the dial plate; then tighten locknut. The valve handle may then be moved to admit sufficient steam to heat a quarter, half, three-quarter, or entire radiator. The valve stem stuffing box has a frictionless metallic fibre packing that will last indefinitely and require no attention, giving at the same time, a valve action so free that the pressure of only one finger is required to open the valve.

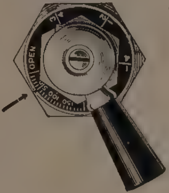
TOP DIAL PLATE ADJUSTMENT



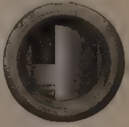
Dial set for 200 sq. ft.



Port Area for 200 sq. ft. Radiator



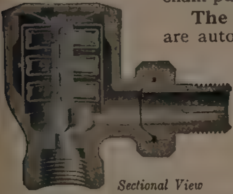
Dial set for 50 sq. ft.



Port Area for 50 sq. ft. Radiator

The visible adjustment aids the designing engineer by enabling heating contractor to make a final accurate adjustment which compensates for slight irregularities in pipe sizes, failure to ream pipe, installation of extra fittings not foreseen in original layout, etc. The advantages of an adjustable port in forced hot water systems to secure proper balance makes the **No. 7 Valve** especially adaptable for such use.

The No. 7 Valve is regularly supplied with lever handle. On special orders, it can be furnished with wood wheel, lock shield, closed top, extension stem and handle, or chain pull.



Sectional View
Nos. 8 and 9 Return Line Valves

The Nos. 8 and 9 Hoffman Return Line Valves—These valves are automatic, non-adjustable, thermostatic and relieve all air and condensation without the loss of steam from radiators, pipe coils, indirect radiation, steam mains and risers, steam kettles, sterilizers and other devices where it is desired to get full efficiency and economy without waste of steam.

In service, they have established a reputation for efficiency and consistency of operation with the same degree of sensitiveness under either high or low pressure.

The body of the valve is made of cast steam metal; cap and tail piece are hot brass forgings; the thermostat of a special Hoffman alloy. In continued operation the thermostats will not break, stretch or lose their tension, giving long life and perfect operation.

CHIEF FEATURES

The valve consistently operates under a pressure range from 13 in. of vacuum to 50 lb. steam pressure. Water at a temperature of approximately 12 deg. less than the temperature corresponding to the steam pressure causes full valve opening and free discharge of condensation.

Write for Descriptive Circular—Hoffman "Controlled Heat"

HOFFMAN "CONTROLLED HEAT" EQUIPMENT

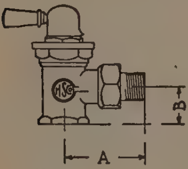
Nos. 8 and 9 Hoffman Return Line Valves (continued)

Interchangeable Thermo Member

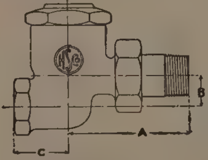
The thermostatic member is removable and may be changed from one valve to another of the same size without adjustment. This feature is appreciated by engineers who require the removal of the thermostat from the valves, until the system is thoroughly cleaned, and likewise by contractors complying with this practice.

The No. 8 Valve has ½ in. pipe connections, ¼ in. port and is furnished in Angle, Straightway, Right and Left-hand Offset Patterns. The normal capacity is 200 sq. ft. of cast iron radiation.

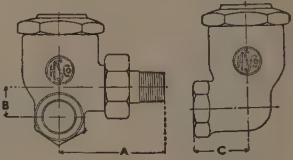
The No. 9 Valve with ¾ in. connection is made in Angle and Straightway Patterns only, and is suitable for 600 sq. ft. of cast iron radiation. For pressures up to 15 lb. valve has ⅜ in. port, for higher pressures 3/16 in. port.



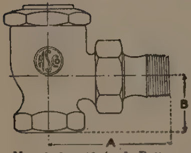
No. 7 Angle Pattern



Nos. 8, 9 or 18 Straightway Pattern



Nos. 8 or 18 Right or Left Offset Pattern



Nos. 8, 9 or 18 Angle Pattern

Data and Dimensions

Style	Size In.	Diameter Valve Port In.	Maximum Capacity Sq. Ft.	Dimensions		
				A	B	C
No. 7 Angle	3/4	..	200	2 7/8†	1 3/8	...
No. 19 Angle	3/4	..	200	2 3/4†	1 1/2	...
No. 8 Angle	1/2	1/4	200	2 23/32†	1 9/32	...
No. 8 Straightway	1/2	1/4	200	2 23/32†	25/32	1 13/32
No. 8 Offset	1/2	1/4	200	2 23/32†	25/32	1 5/16
No. 18 Angle	1/2	1/4	100	2 3/4†	1 1/4	...
No. 18 Straightway	1/2	1/4	100	2 3/4†	7/8	1 3/8
No. 18 Offset	1/2	1/4	100	2 3/4†	7/8	1 3/8
No. 9 Angle	3/4	3/8*	600	3 3/32	1 11/32	...
No. 9 Straightway	3/4	3/8*	600	3 3/32	...	...

*No. 9 Valve furnished with 5/16 in. port for pressures above 15 lb.
†Nos. 7, 19, 8 and 18 Valves can be supplied where specified to meet standard roughing measurements of National Heating and Piping Contractors' Association.

The No. 11 Hoffman Vapor Vacuum Valve is used for venting the return mains in vapor vacuum systems or for other conditions where a large venting capacity is required and where return of air through vent port must be prevented. The vent port is ¾ in. in diameter.

Pipe connection, ¾ in. Maximum guaranteed operating pressure, 15 lb.

NO. 15 VALVE

In conjunction with the Loop a special valve for venting the entire system is used—the No. 15 Hoffman Vacuum Valve—which permits free venting of air through its ¾ in. vent port and prevents air returning to the system by means of a light check, which is thoroughly reliable in fulfilling its requirements.

The No. 15 Valve is intended for use only in connection with Hoffman Differential Loops.

No. 15

No. 11

HOFFMAN DIFFERENTIAL LOOP

Hoffman Differential Loop

The Differential Loop is the safety device for maintaining a steady water line in vapor and vapor vacuum systems. It is entirely automatic, non-adjustable and has no moving parts to stick at a critical moment.

In operation the water rises in the return main **only** to a certain predetermined height. The loop then functions, blowing over a small quantity of steam which closes the No. 15 Valve used for venting the system and then compresses the air which is "bottled up" in the return main and builds up a pressure which prevents further rise of water in the vertical part of the return beyond the predetermined amount. As soon as this is accomplished, and the action is almost instantaneous, the loop reseals and no more steam is blown over until the differential pressure is slightly reduced. It will be readily seen that, by the alternate blowing over and resealing of the loop, a constant differential pressure will be maintained between the steam main and return main. Also by the maintenance of this differential no matter how high the boiler pressure goes, circulation will start in a radiator as soon as the inlet valve is opened even though the return main vent is closed through loop action.

Standard Differential Loops are made in four sizes, to handle systems up to 15,000 sq. ft. of radiation. For larger systems the No. 04 Loops can be installed in a battery.

No. 01 and No. 02 Loops should not be used where the low point in the dry return is less than 24 in. above boiler water line; with the No. 03 and No. 04 Loops this distance must be at least 30 in.

HOFFMAN DAMPER REGULATOR

Hoffman Damper Regulator

One of the most important features of the Hoffman Damper Regulator is the accurate pressure control and resultant fuel economy.

It is extremely sensitive in its action and controls so efficiently that when inlet valves are turned on or off, the fire is accelerated or retarded to meet the change in demand for vapor. A low constant pressure is always maintained so that vapor enters the radiator as soon as a valve is turned on.

The compensating or balancing plate is like a pair of scales. It is practically frictionless, remarkably sensitive and operates on slight changes in pressure.

It has an additional feature for the convenience of the installing fitter, in that the fulcrum on which the lever is suspended may be turned at different angles, permitting a straight chain connection with the dampers instead of at an angle, which might cause the dampers to bind.

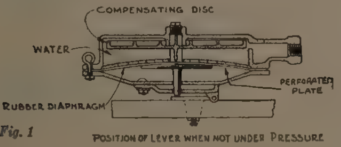


Fig. 1

Fig. 1 shows Damper Regulator under no pressure. Compensating disc is in its uppermost position, the bottom of the disc being in line with bottom of inlet. The space above diaphragm is filled with water up to the inlet. Weights on lever are to be so placed that they will hold the diaphragm against the perforated plate. Drafts are held open until the predetermined pressure is generated, when through diaphragm action which in turn is transmitted to the lever, drafts are closed.

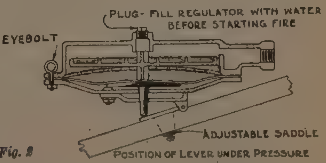

PLUG- FILL REGULATOR WITH WATER BEFORE STARTING FIRE
EYEBOLT
ADJUSTABLE SADDLE
POSITION OF LEVER UNDER PRESSURE

Fig. 2

Fig. 2 shows position of Damper Regulator when drafts are closed. Vapor pressure has overcome upward force exerted by the weights on lever arm and forced diaphragm downward. The water on the diaphragm lowers with it and likewise the compensating disc until top of the disc is level with the bottom of the inlet, thus preventing any addition to the water above the diaphragm. With a slight drop in vapor the weights force the diaphragm upward and drafts are opened.

Write for Descriptive Circular—Hoffman "Controlled Heat"

Hoffman Kompo-Gage

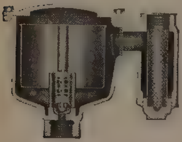
HOFFMAN KOMPO-GAGE

Measures pressure up to 30 lb., vacuum to 30 in. Pressure is registered in ounces up to 5 lb. Vacuum is shown in half inches up to 10 in.

Used in Hoffman "Controlled Heat" installations or in one-pipe gravity vacuum systems equipped with No. 2 valves; indicates efficiency of the apparatus when a warm house is maintained with vapor at temperatures considerably below 212 deg.

The No. 12 Hoffman Blast Trap is adapted for draining condensation from Indirect Radiators, Dryers, Drums, Blast Coils, Unit Heaters, Hot Water Generators and Ends of Long Steam Mains or Risers.

The Trap embodies the desirable feature of open bucket or float traps because it relieves condensation immediately upon its arrival at the trap regardless of the water temperature. Coupled with the float is a thermostatic member which positively overcomes the chief difficulty with float traps by automatically relieving air as well as condensation from the system.



No. 12 Hoffman Blast Trap

Table of Nominal Capacities, No. 12 Hoffman Blast Trap

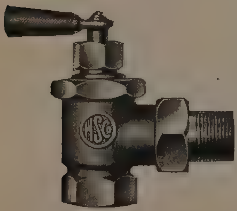
Pressure, Pounds per Square Inch	½	1	2	3	4	5
Capacity, Pounds per Hour	800	1000	1500	1800	2000	2500
*Capacity, Square Feet Radiation	3200	4000	6000	7200	8000	10000

Maximum Operating Pressure, 30 lb. Capacities for over 5 lb. pressure, furnished on application.

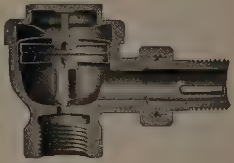
With Strainer: inlet connection, 1 in.; outlet, 1 in.

*On the basis of ¼ lb. of condensation per square foot per hour.

No. 19 Quick Opening Hoffman Radiator Valve is of the semi-packless type for vacuum pump installations or for vapor systems where modulation is not required. Made in ¾ in. size only, capacity up to 200 sq. ft. C. I. Radiation. Regularly furnished in Lever Handle pattern. Wood Wheels or Lock Shields furnished on special order without extra charge. Extension stems supplied at an extra charge.



No. 19 Hoffman Radiator Valve

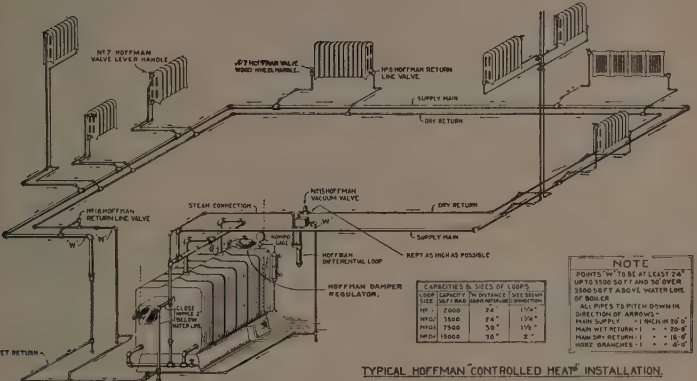


No. 18 Hoffman Radiator Trap

No. 18 Hoffman Return Line Valve or Radiator Trap is similar in principle to the No. 8 Valve. It is intended for pressures up to 15 lb. and radiators up to 100 sq. ft. Thermostats are interchangeable and made of special Hoffman Diaphragm Metal that will not soften, stretch or crack under repeated action. Made with ½ in. connections in Angle, Straightway, Right- and Left-hand Offset Patterns. For roughing measurements see page (802).

Write for Descriptive Circulars

TYPICAL INSTALLATION
HOFFMAN "CONTROLLED HEAT" EQUIPMENT


Nº 7 HOFFMAN VALVE LEVER HANDLE
Nº 7 HOFFMAN VALVE WOOD WHEEL HANDLE.
Nº 8 HOFFMAN RETURN LINE VALVE
SUPPLY MAIN
DRY RETURN
Nº 15 HOFFMAN VACUUM VALVE
STEAM CONNECTION
Nº 18 HOFFMAN RETURN LINE VALVE
DRY RETURN
'W'
'W'
'W'
SUPPLY MAIN
KOMPO GAGE
HOFFMAN DIFFERENTIAL LOOP
KEPT AS HIGH AS POSSIBLE
HOFFMAN DAMPER REGULATOR.
CLOSE NIPPLE 2" BELOW WATER LINE
WET RETURN
CAPACITIES & SIZES OF LOOPS
LOOP SIZE | CAPACITY SQ FT RAD | W DISTANCE ABOVE WATER LINE | SIZE STEAM CONNECTION
Nº 0 | 2000 | 24" | 1¼"
Nº 02 | 3500 | 24" | 1¼"
Nº 03 | 7500 | 30" | 1½"
Nº 04 | 15000 | 30" | 2"
NOTE
POINTS "W" TO BE AT LEAST 24" UP TO 3500 SQ FT AND 30" OVER 3500 SQ FT ABOVE WATER LINE OF BOILER
ALL PIPES TO PITCH DOWN IN DIRECTION OF ARROWS –
MAIN SUPPLY – 1 INCH IN 20'0"
MAIN WET RETURN – 1 " " 20-0"
MAIN DRY RETURN – 1 " " 15-0"
HORZ BRANCHES – 1 " " 4-0"
TYPICAL HOFFMAN "CONTROLLED HEAT" INSTALLATION.

NOTE.—Loop discharges into high end of return main. This results in venting air from high point in return instead of low point. Point "W" should be at least 24 in. above water line with Nos. 0 and 02 loops and 30 in. with Nos. 03 and 04.

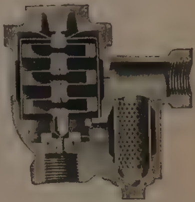
NOS. 20 AND 21 HOFFMAN THERMOSTATIC STEAM TRAPS

Pressure Range 0 to 100 lb. Without Change or Adjustment

The Hoffman Steam Trap Body is of strong, rugged all bronze construction. The diaphragms in the thermostat, the valve pins and valve seat are all made of the same non-corrosive alloy which has been successfully used for diaphragms in Hoffman Valves for a number of years. The alloy withstands high temperature steam, and repeated action without softening or cracking. It also withstands the scoring action of steam.

A strainer is built into the trap body permitting ready removal for cleaning. All renewable parts are interchangeable, permitting replacement without adjustment of any sort. The trap is built to give maximum service with minimum attention and when repairs or cleaning are required the work can be quickly done.

The Hoffman Steam Trap normally has a wide open vent port which is maintained until all air and condensation is relieved from the system, after which steam contact with the thermostat closes the port. No hand operated by-passes are required to vent air from the system. The trap cannot air-bind or freeze.



Nos. 20 and 21
Hoffman Thermostatic Steam Trap

The discharge capacity is dependent upon differences between the temperature of condensation delivered to the trap and steam temperature, the greater the difference the larger the capacity of the trap. The following table gives continuous discharge capacities in pounds per hour.

	NO. 20 TRAP						NO. 21 TRAP					
Pressure, lbs. per sq. in.	10	30	50	70	90	100	10	30	50	70	90	100
Temperature Drop 20°	275	550	715	820	900	925	375	725	925	1085	1190	1225
Temperature Drop 35°	725	1075	1380	1675	1830	1860	950	1410	1860	2250	2490	2550

No. 20 Trap has ½ in. pipe connections, ⅜ in. port. Weight 3¼ lb.
No. 21 Trap has ¾ in. pipe connections, ¼ in. port. Weight 3¾ lb.

Write for Descriptive Circulars

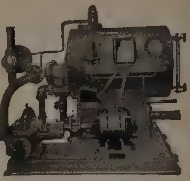
HOFFMAN-ECONOMY RETURN LINE VACUUM PUMPS

The jet type vacuum producer used in these pumps is one of the simplest and best known methods for exhausting air and vapors. It has no moving parts and avoids close clearances so that loss of efficiency, due to wear, is reduced to a minimum. Pumps will handle extremely hot water and are smooth and quiet in operation.

All units of 16,000 sq. ft. and over have horizontal split case pumps with enclosed, double suction, bronze impellers. SV-1, 2 and 3-A units have vertically split volute pumps, with enclosed impeller, removable bronze stand bearing and outboard ball bearing. Operation is controlled by float switch and vacuum regulator.

All standard units are for 20 lb. discharge pressure. Also furnished in Duplex Units.

When returns are below pump inlet an auxiliary accumulator tank will permit operation on float control only. All units completely assembled and wired ready for installation.



Capacity Table—Vacuum Pumps

Pump No.	Capacity Sq. Ft. Dir. Cast Iron Rad.	Water Cap. G. P. M.	Air Cap. C. F. M.	Motor H. P. 20. lb. Press.
SV-1	2500	5	1¾	¾
SV-2	5000	9	4	1
SV-3-A	12,000	16	7	1½
SV-4	16,000	20	10	2
SV-5	20,000	25	15	3
SV-6	26,000	35	19	5
SV-7	40,000	60	24	5
SV-8	65,000	100	40	7½
SV-9	100,000	150	60	10
SV-10	150,000	225	90	15
SV-11	250,000	375	150	25

HOFFMAN-ECONOMY HORIZONTAL CONDENSATION PUMPS

Horizontal Condensation Pumps are made in Styles "A"—0 to 20 lb. pressure—"B"—"C" and "D" for 35 to 100 lb. pressure. All units have bronze fitted, enclosed impellers. Styles A-B and C have vertically split case—Style D horizontal split case. Style A pumps have outboard ball bearing and self-lubricating, renewable bronze stand bearing. Style B and C have double outboard bearings, ring oiling at driving end and ball bearing at opposite end, both readily renewable. Style D has double outboard ring oiling bearings, both easily renewable.

Float switch mechanism is positive with bronze float arm supported by two liberal bearings. All units are completely assembled and wired, ready for installation.

Style "A"

Capacity Table—Condensation Pumps—60 Cycle and Direct Current

Pump and Style No.	Capacity Sq. Ft. Dir. C. I. Radiation	Disc. Press. Lbs. Sq. In.	Pump Cap. G.p.m.	Motor H. P.	Speed R.p.m.
10A	1,000	10	2	¼	1,750
30A	3,000	10	5	¼	1,750
31A	3,000	15	5	½	1,750
32A	3,000	20	5	¾	1,750
60A	6,000	10	12	¼	1,750
61A	6,000	15	12	½	1,750
62A	6,000	20	12	¾	1,750
64B	6,000	30	12	1	1,750
65B	6,000	40	12	1½	1,750
65C	6,000	40	12	1½	3,500
66B	6,000	50	12	2	1,750
66C	6,000	50	12	2	3,500
67B	6,000	60	12	3	1,750
67C	6,000	60	12	3	3,500
68C	6,000	75	12	3	3,500
69C	6,000	100	12	5	3,500

Pump and Style No.	Capacity Sq. Ft. Dir. C. I. Radiation	Disc. Press. Lbs. Sq. In.	Pump Cap. G.p.m.	Motor H. P.	Speed R.p.m.
100A	10,000	10	20	¼	1,750
101A	10,000	15	20	½	1,750
102A	10,000	20	20	¾	1,750
103B	10,000	25	20	1	1,750
104B	10,000	30	20	1½	1,750
105B	10,000	40	20	1½	1,750
105C	10,000	40	20	1½	3,500
106B	10,000	50	20	2	1,750
106C	10,000	50	20	2	3,500
107B	10,000	60	20	3	1,750
107C	10,000	60	20	3	3,500
109C	10,000	100	20	5	3,500
151A	15,000	15	30	½	1,750
152A	15,000	20	30	¾	1,750
153B	15,000	25	30	1	1,750
155B	15,000	40	30	2	1,750
155C	15,000	40	30	2	3,500
157B	15,000	60	30	3	1,750
157C	15,000	60	30	3	3,500
159C	15,000	100	30	5	3,500

Pump and Style No.	Capacity Sq. Ft. Dir. C. I. Radiation	Disc. Press. Lbs. Sq. In.	Pump Cap. G.p.m.	Motor H. P	Speed R p.m.
200A	20,000	10	40	½	1,750
201A	20,000	15	40	¾	1,750
202A	20,000	20	40	1	1,750
203B	20,000	25	40	1½	1,750
205B	20,000	40	40	2	1,750
205C	20,000	40	40	2	3,500
207B	20,000	60	40	3	1,750
207C	20,000	60	40	3	3,500
209C	20,000	100	40	5	3,500
300A	30,000	10	53	½	1:750
301A	30,000	15	53	¾	1,750
302A	30,000	20	53	1	1,750
303A	30,000	25	53	1½	1,750
304A	30,000	30	53	2	1,750
307C	30,000	60	53	5	3.500
308C	30,000	75	53	7½	1.750
309B	30,000	100	53	10	1,750

Complete Tables and Specifications for Pumps up to 70,000 sq. ft. capacity,
Given in Our 1930 General Catalogue

HOFFMAN-ECONOMY VERTICAL UNDERGROUND COND. PUMP

Where return lines are located below the floor, or otherwise too low for Horizontal Condensation Pumps, the Vertical Underground Pump should be used. No concrete pit is required as receiver is of heavy cast iron suitable for underground use.

Ball bearing pump shaft is mounted in dust proof housing. Lower bearing is self lubricating and renewable without removing impeller from shaft or dismantling pump. Can be furnished in duplex unit or for high pressure by addition of horizontal booster pump. Float switch mechanism same as in Horizontal pumps.

Completely assembled and wired, ready for installation.

Capacity Table—Vertical Underground Condensation Pumps

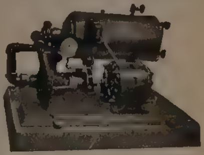
Pump No.	Capacity Sq. Ft. Dir. C. I. Rad.	Pump Cap. G. P. M.	H. P. 10 lb. Dis. Pr.	Recvr. Dim. Ins.	Pump No.	Capacity Sq. Ft. Dir. C. I. Rad.	Pump Cap. G. P. M.	H. P. 10 lb. Dis. Pr.	Recvr. Dim. Ins.
U-30	3000	6	¼	16 x 30	U-120	12,000	24	½	24 x 36
U-50	5000	10	¼	16 x 30	U-200	20,000	40	½	24 x 36
U-80	8000	16	¼	18 x 30	U-300	30,000	60	1	30 x 36

HOFFMAN-ECONOMY AIR LINE VACUUM PUMPS

Capacity Table—Air Line Pumps

Pump No.	Capacity Sq. Ft. Direct Radiation	Air Capacity Cu. Ft. per Min.	Motor H. P.
AL-1	4000	1¾	¾
AL-2	8000	4	1
AL-3	12,000	6	1½
AL-4	20,000	10	2
AL-5	30,000	15	3
AL-6	40,000	20	5
AL-7	60,000	30	5
AL-8	80,000	40	7½
AL-9	150,000	70	10

Hoffman-Economy Air Line Pumps are used for rapid removal of air from gravity installations using No. 3 Hoffman or "Paul" type air line valves. Does not handle condensate nor act as boiler feed pump.



Made in single or duplex units with capacities from 4,000 to 150,000 sq. ft. radiation.

HOFFMAN-ECONOMY RECIPROCATING COND. PUMP

Hoffman-Economy Reciprocating Condensation Pumps are widely used in laundries, cleaning and dyeing establishments, etc., where steam pressures of 50 to 100 lb. are carried. These units are low in cost but are not as quiet as Centrifugal type, due to the slight pulsation at end of stroke and chain drive. Standard sizes range from 1,000 to 10,000 sq. ft. of radiation with discharge pressures of 50 and 100 lb. in each size.

Capacity Table—Reciprocating Pumps

Pump No.	Capacity Sq. Ft. Direct Radiation or Equiv.	Discharge Pressure Lbs. per Sq. In.	Pump Capacity Gals. per Min.	Motor H. P.	Receiver Capacity Gals.
R- 11	1,000	50	2	½	9
R- 12	1,000	100	2	¾	9
R- 31	3,000	50	5	½	13
R- 32	3,000	100	5	¾	13
R- 61	6,000	50	10	½	20
R- 62	6,000	100	10	1	20
R-101	10,000	50	16	1	26
R-102	10,000	100	16	2	26

HOFFMAN THERMADOR ELECTRIC HEATER

An abundance of clean electrically heated air at the touch of a switch, and concentration of the warmed air in the lower, or living zone of the room, are features that make the Thermador an outstanding achievement among electric heating devices.

By drawing up colder air from the floor level, warming it and then distributing it directly in the "living zone" a large percentage of the air is constantly recirculated, confining it to the zone of usefulness and eliminating waste due to overheating the upper, or unoccupied portion of the room.

Special Catalogue Furnished on Application

HOFFMAN MOTO HEATERS

Front View No. 2, 4 and 5

Hoffman-Moto-Heaters correct the "upside down" heating results often found in garages, industrial plants, and other high ceiling buildings where gravity air circulation is used. Moto-Heaters distribute the heated air directly in the "working zone" reducing to a minimum the waste heat in the upper areas.

The heating element consists of smooth copper fins, 1½ in. outside diameter embedded in copper tubing without the use of solder, forming a three-side metal to metal contact. The tubes are united to steel headers by actual fusion of metal eliminating expanded joints and all danger of leakage. Every heater is tested under 1,000 lb. per sq. in. hydrostatic pressure, and is guaranteed for any operating steam pressure up to 200 lb. per sq. in.

Flexibility of output is provided in the Nos. 6, 7 and 8 Moto-Heaters which are equipped with two fans, as follows, 100 per cent total output with both fans running, 55 per cent with one fan and 6 per cent with no fans running.

Moto-Heaters are made in six sizes and except the No. 2, each size is supplied in three types—suspended, floor mounted recirculating box and horizontal outside air intake box.

A selection of three motor speeds, 1750, 1160 and 870 is available depending upon the degree of quiet operation the application demands.

Rear View No. 6, 7 and 8

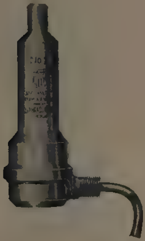
Steam Pressure at Heater—2 Lb. Sq. In.

1750 R.P.M.						1160 R.P.M.						870 R.P.M.					
Entering Air	Leaving Air	B.t.u. Output	Cond. Lbs. Hr.	C.f.m. at Entering Air Temp.	H. P.	Entering Air	Leaving Air	B.t.u. Output	Cond. Lbs. Hr.	C.f.m. at Entering Air Temp.	H. P.	Entering Air	Leaving Air	B.t.u. Output	Cond. Lbs. Hr.	C.f.m. at Entering Air Temp.	H. P.
MOTO-HEATER NO. 2																	
60	112	40,000	41	700	1/15	60	117	29,400	30	465	1/30	60	121	23,600	24	350	1/40
70	119	37,100	38	700	1/15	70	124	27,200	28	465	1/30	70	128	21,900	23	350	1/40
80	126	34,100	35	700	1/15	80	130	25,000	26	465	1/30	80	134	20,100	21	350	1/40
MOTO-HEATER NO. 4																	
60	109	92,000	95	1,700	1/6	60	115	69,000	72	1,130	1/8	60	121	57,000	59	850	1/10
70	116	85,200	88	1,700	1/6	70	122	63,900	66	1,130	1/8	70	127	52,800	55	850	1/10
80	123	78,500	81	1,700	1/6	80	129	58,800	61	1,130	1/8	80	134	48,600	50	850	1/10
MOTO-HEATER NO. 5																	
60	114	110,000	114	1,850	1/6	60	121	83,500	87	1,230	1/8	60	127	68,500	71	920	1/10
70	121	102,000	106	1,850	1/6	70	128	77,400	80	1,230	1/8	70	134	63,500	66	920	1/10
80	128	93,900	97	1,850	1/6	80	134	71,200	74	1,230	1/8	80	140	58,500	61	920	1/10
MOTO-HEATER NO. 6																	
60	97	153,000	158	3,740	1/3	60	102	115,000	119	2,480	1/4	60	106	95,300	99	1,860	1/5
70	105	141,500	146	3,740	1/3	70	110	106,500	110	2,480	1/4	70	114	88,200	91	1,860	1/5
80	113	130,000	134	3,740	1/3	80	117	98,400	102	2,480	1/4	80	121	81,200	84	1,860	1/5
MOTO-HEATER NO. 7																	
60	111	197,000	203	3,490	1/3	60	118	150,000	155	2,320	1/4	60	124	124,000	128	1,740	1/5
70	118	182,500	189	3,490	1/3	70	125	139,000	144	2,320	1/4	70	131	114,500	118	1,740	1/5
80	125	168,000	174	3,490	1/3	80	132	128,000	132	2,320	1/4	80	137	103,500	109	1,740	1/5
MOTO-HEATER NO. 8																	
60	126	236,000	244	3,240	1/3	60	134	177,000	183	2,150	1/4	60	142	145,500	150	1,610	1/5
70	132	218,500	226	3,240	1/3	70	140	164,000	169	2,150	1/4	70	147	134,500	139	1,610	1/5
80	138	201,500	208	3,240	1/3	80	146	151,000	156	2,150	1/4	80	152	124,000	128	1,610	1/5

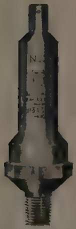
Complete Capacity Tables for Various Pressures Given in Our 1930 General Catalogue

Kelly Brass Works

226-232 West Ontario Street
Chicago, Ill.



No. 1—⅛-in. Side-Outlet Air Valve for Radiators



No. 3—¼-in. Bottom-Outlet Air Valve for Mains, Coils and Risers

Kelly Non-Adjustable Steam, Air and Vacuum Valves

All Cuts One-Third Size

"Kelly" Air Valves will fill every valve requirement.

The complete line of Kelly Non-Adjustable Automatic Steam, Air and Vacuum Valves are manufactured complete by the Kelly Brass Works.

The interior construction of "Kelly" Air Valves are identical. The float is sealed with a phosphor bronze diaphragm at the bottom. A definite amount of volatile liquid is placed in the float before sealing which vaporizes from the heat of the steam causing the diaphragm to expand and raise the float thereby closing the escape port in the top of the valve.

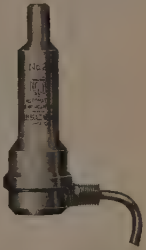
"Kelly" Air Valves will operate under all pressures up to 10 pounds venting the radiator of the accumulated air and closing against steam and water. Any water of condensation in the valve will be drained back to the radiator through the syphon tube.

Your particular attention is called to the "Kelly" No. 2 Vacuum Valve.

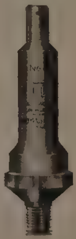
Simplicity of parts. Absolutely positive in action.

"Kelly" Air Valves are subjected to practical steam and vacuum tests before shipping and are

Guaranteed for Five Years



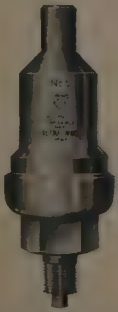
No. 2—Vacuum—⅛-in. Side-Outlet Air Valve for Radiators



No. 4—Vacuum—¼-in. Bottom-Outlet Air Valve for Mains, Coils and Risers

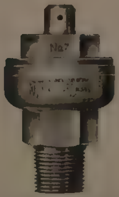
Complete Satisfaction

Scientific Construction



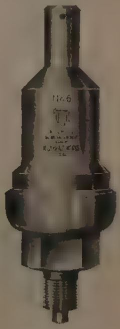
No. 5—⅜-in. Bottom-Outlet Quick Vent Air Valves for Mains and HV Stacks

Note.—Contains Float—will close against water.



No. 7—¾-in. Bottom-Outlet Quick Vent Air Valve for Mains and HV Stacks

Note.—Will not close against water.



No. 6—Vacuum—⅜-in. Bottom-Outlet Quick Vent Air Valve for Mains and HV Stacks

Note.—Contains Float—will close against water.

Illinois Engineering Company

General Offices and Factory: CHICAGO

Branches and Representatives

Akron
Atlanta
Baltimore
Birmingham
Boston
Buffalo
Cincinnati
Cleveland
Columbus
Dallas
Dayton
Denver
Detroit
El Paso
Grand Rapids
Greensboro
Halifax
Harrisburg
Houston
Indianapolis
Kansas City
Knoxville
Little Rock
Los Angeles
Memphis
Milwaukee
Minneapolis
Montreal
New Orleans
New York City
Oklahoma City
Omaha
Peoria
Philadelphia
Pittsburgh
Portland
Richmond (Va.)
Rochester
St. Louis
Salt Lake City
San Francisco
Scranton
Seattle
Shreveport
South Bend
Spokane
Toledo
Toronto
Tulsa
Wichita Falls
Youngstown

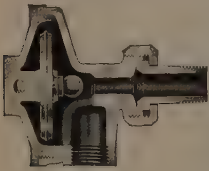
PRODUCTS—Illinois Heating Systems—Eclipse Steam Specialties

Illinois Heating Systems

Successfully installed in thousands of buildings—the result of over 25 years of special work in this line, and the ultimate in efficiency and economy.

Illinois Thermo Trap

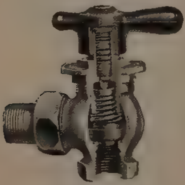
The original vertical seat trap. Dirt does not lie on seat—self cleaning, non-adjustable, positive in operation; durable, will stand 50 lb. steam pressure which shows the great strength of the diaphragm, which is the reason for the long life and durability of these Traps. Thousands in operation for over 15 years without diaphragm replacements.



Thermo Trap

Illinois Modulating Supply Valve

Quick Opening—only a half turn of handle from open to closed position. Packless, Bakelite handle, steam tight on 50 lbs. pressure. Large diameter of thread spool and machine cut threads make valve easy of operation.



Modulating Valve

The improved Bakelite handle insulates the hand from heat.

The graduated dial shows the open or closed or any position of the valve.

Furnished with Lock Shield and Key, or with Bakelite Wheel handle, upon order.

Illinois Vapor Systems

Illinois Vapor Systems are capable of operating automatically on any pressures possible in a low pressure heating system—from 10 lb. to 20 in. of vacuum. Our improved equipment actually insures operation under vapor—less than atmospheric pressure—with only two or three firing periods per 24 hrs. The advantages are healthful, modulated heat, and a *fuel saving of 25-30 per cent* over other systems of heating. This result is secured by the ILLINOIS HEAT RETAINOR—Browne Patent, a device which marks an epoch in the heating art.

Illinois Heat Retainor

This improved device not only vents air from the System on ⅛ oz. pressure, but it absolutely prevents air pulling back into the System, thus allowing the System to remain under vacuum for hours at a time.

Illinois Heat Retainor

No dirt or scale can reach the valve of the Retainor, and even the air passing through same is washed, so this device will remain in operative condition over long periods.

Our Bulletin No. 22, describes the operation in detail—Copy sent upon request.

Illinois Return Trap or Alternating Receiver

This device automatically puts the water back in the boiler against any boiler pressure possible in a low pressure heating system.

The float trips the weights which in turn positively operate the valves. The operation is forceful and positive and this mechanism cannot be caught on dead centre by water half filling the tank. No external parts to be adjusted or tampered with. No stuffing boxes—all working parts enclosed in the tank.

Illinois Return Trap

Our Sales-Engineering Organization will be glad to give detailed technical information regarding our products and to advise as to their proper installation.

ILLINOIS PRODUCTS—Eclipse Steam Specialties

Eclipse Steam Specialties

The old John Davis Co. Eclipse Steam Specialties have been on the market for over 40 years, and embody the improvements and refinements suggested by this long period of service. These Specialties are quality products, having bronze and monel metal pistons, seat rings and valve parts, the bodies are extra heavy, and every piece of apparatus is carefully steam tested—under working pressure where same is given—before shipment.

Pressure Reducing Valves, for all pressures and services.

Back Pressure, and *Atmospheric Relief Valves.*
Separators, Oil and *Steam, Cast Iron* and *Steel.*
Steam Traps, all pressures.
Non-Return or *Stop* and *Check Valves.*
Pump Governors, Balanced Valves.
Float Valves, Expansion Joints, Pipe Strainers.

Reducing Valve

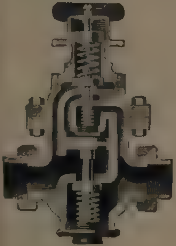
Reducing Valves. In general use on Vacuum or low pressure Heating Systems. Will reduce to 4 oz. pressure from even 150 lb. initial pressure.

The large diaphragm insures sensitive operation.

Made in both straightway and expanded outlet bodies.

Sizes ¾ in. to 12 in.

Eclipse Master Reducing Valve



A pilot type valve will reduce from any pressure up to 250 lb. down to 10 lb. and hold reduced pressure constant at all times—even against a "dead end" pipe.

Made of Bronze with monel valves and trimmings.

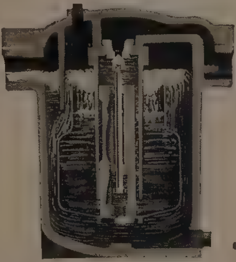
Sizes ½ in. to 6 in.

Illinois Expansion Joints - Single and Double Traverse

Heavy duty joints, the liners are cast bronze—not brass tubing. The bolts are through bolts, no stud bolts used.

Tapped for service connections in anchor section if desired.

Eclipse Steam Trap

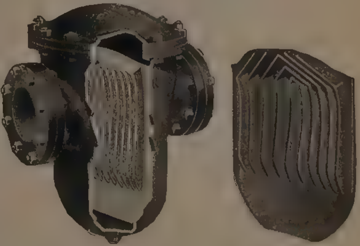


Something new in Steam trap design. The valve and stem are separate from the bucket and only operated by the bucket at its extreme top and bottom travel —*Result*—

Valve is always either full open or tight closed.

No wire drawing or cutting of valve and seat, which are of Monel metal. Steam tight and long lasting.
Bulletin No. 33 describes in detail.

Horizontal Oil Separator

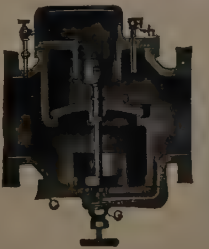


These Separators have a baffle removable without disturbing the piping. Occasional cleaning is necessary for proper elimination of oil.

The port areas are over 3 times the diameter of the pipe area, hence these separators are effective.

Eclipse Back Pressure and Combination Relief Valves

Made in Vertical and Horizontal types, straightway or angle pattern, for condensing and non-condensing engines.



It is noiseless and works equally well on pressure or vacuum, air cushioned by back pressure in dashpot. Constructed entirely of metal with no springs; wearing parts of special bronze.

Size 4 in. to 36 in.

Catalog and Bulletins—Illinois Heating Systems—144 pages

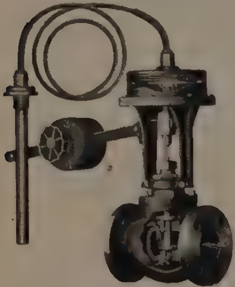
BULLETINS

No. 14—Heating Specialties.
No. 22—Vapor System Details.
No. 45—Non-Return Valves.
No. 104—Pressure Reducing Valves.
No. 204—Back Pressure, and Relief Valves, Exhaust Heads.
No. 34—Steam Traps.
No. 54—Separators—Oil and Steam.
No. 204—Float and Balanced Valves.

Klipfel Manufacturing Co.

2641-2659 West Harrison Street :-: Chicago, Ill.

Manufacturers of Automatic Valve Specialties

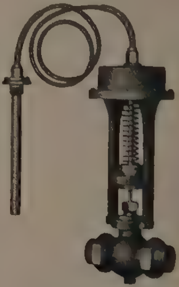


No. 48 Vapor Thermostat, Lever Type

Sizes: ½ to 8 in., inclusive. Bronze bodies in sizes 1½ in. and under, union connections only. Iron bodies in sizes 2 in. and above, flanged ends only.

No. 48 Vapor Thermostats.—Automatically maintain hot water in steam heated tanks at any desired temperature between 140° and 180°; but can be made special for other temperatures. A complete operating unit within itself—it is self-contained. No compressed air, water, electrical, or other auxiliary power required. Lever of lever type is fitted with roller bearings to insure frictionless operation.

The sensitive all-metal bellows will move the inner valve farther on a given temperature-pressure change than any competing bellows of the same diameter and length.



No. 49 Vapor Thermostat, Spring Type

Sizes: ½ to 2½ in., inclusive. Bronze bodies in sizes 1½ in. and under, union connections only. Iron bodies in sizes 2 in. and above, flanged ends only.

No. 49 Vapor Thermostats.—Similar to the No. 48 Vapor Thermostat, except that a spring is used instead of a lever and weight. The spring type may be used where space does not permit the use of the lever type and where extreme sensitiveness and a wide range of temperature adjustment are not required. The semi-balanced, bevel seated, bronze inner valve is normally held open by a spring. An increase of temperature of a volatile fluid hermetically sealed within the temperature sensitive bulb, which is installed in contact with the medium, causes the bellows to expand and operate the inner valve.

No. 1 Pressure Regulators.—Automatically reduce any initial steam, air or water pressure to any desired reduced pressure down to 2 lb. and maintain reduced pressure constantly regardless of fluctuations in initial pressure, or changes in the demand for steam. When specified for the control of air or water, the piston is provided with special leather cup packing.

Can be furnished with expanded outlet in sizes 1x2 to 12x24 in., inclusive.

No. 1 Pressure Regulator, Piston Type

Sizes: ⅜ to 14 in., inclusive. Bronze bodies in sizes 1½ in. and under, screwed ends only. Iron bodies in sizes 2 in. and above; 2 to 6 in., inclusive, screwed or flanged ends, but screwed ends will be furnished unless otherwise specified; sizes 7 in. and above, flanged ends only.

No. 3 Pressure Regulators.—Automatically reduce any initial steam pressure to any desired reduced pressure, either below atmosphere or up to 5 lb. above atmosphere, and constantly maintain reduced pressure regardless of initial pressure fluctuations or changes in the demand for steam. Includes no packing box, thus eliminating leakage and friction on valve stem. Inner valves and seats are bronze, bevel seated.

Can be furnished with expanded outlet in sizes 1 x 2 to 12 x 24 in., incl.

No. 3 Pressure Regulator, Diaphragm Type

Sizes: ⅜ to 14 in., inclusive. Bronze bodie in sizes 1½ in. an under, screwed end only. Iron bodies i sizes 2 in. and above 2 to 6 in., inclusive screwed or flanged ends but screwed ends will b furnished unless other wise specified; sizes in. and above, flange ends only.

No. 33 Pressure Regulator Spring Type

Sizes: ¾ to 6 in., inclusive. Bronze bodies in sizes 1½ in. and under, screwed ends only. Iron bodies in sizes 2 in. and above; sizes 2 to 6 in., inclusive, are made with screwed or flanged ends, but screwed ends will be furnished unless otherwise specified.

No. 33 Pressure Regulators.—Similar to the No. 3 Pressure Regulator, except that a spring is used instead of a lever and weight. Being equipped with a locking device, they are particularly suited for use under conditions where the adjustment of a lever and weight type might be tampered with. Will reduce any initial steam, air or water pressure to any desired reduced pressure not exceeding 50 lb.

Cannot be used to maintain pressures below atmosphere. Expanded outlet can be furnished.

No. 28 Noiseless Back Pressure Valve

Sizes: 2 to 24 in., inclusive. All sizes made with iron bodies and with flanged ends; sizes 2 to 8 in., inclusive, also made with screwed ends. Unless otherwise specified, sizes 6 in. and under will be shipped screwed ends; sizes 8 in. and above with flanged ends.

No. 28 Noiseless Back Pressure Valves.—Automatically and noiselessly maintain any desired back pressure on exhausts of non-condensing engines. Because of the patented construction, inner valve is effectively stabilized and can not pulsate in unison with the stroke of the engine. Operated in either horizontal or vertical position. Preferable installation is in horizontal pipe line. Iron bodies, bronze inner valves and trimmings.

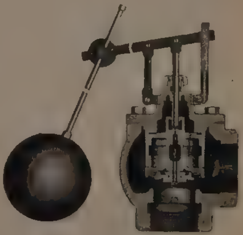
No. 27 Balanced Float Valves.—Automatically control the supply of cold water to open tanks, so as to maintain a practically constant water level. The inner valve consists of two perfectly balanced bronze plunger discs, and is unaffected by the water pressure. Can be furnished with bevel seated valves at an extra price. Angle and globe patterns, with seamless copper float, for working pressures up to 200 lb. Swivel guide yoke can be turned to any position.

No. 27 Balanced Float Valve

Sizes: ⅜ to 20 in., inclusive. Bronze bodies in sizes 1½ in. and under, screwed ends only. Iron bodies in sizes 2 in. and above; 2 to 6 in., inclusive, screwed or flanged ends, but screwed ends will be shipped unless specified otherwise; sizes 7 in. and above, flanged ends, only. All sizes 14 in. and under made angle or globe patterns, but angle pattern will be shipped unless specified globe. Sizes 16 in. and above made globe patterns, only.

No. 7 Single Seated Float Valves.—Automatically maintain a constant level of hot or cold water in open tanks. Single seated, auxiliary operated. Seat equal to pipe size. Swivel guide yoke allows the float to be turned to any position. Includes a packing box with gland to prevent leakage past the valve stem.

Angle and globe patterns, with seamless copper float, for working pressures up to 200 lb.



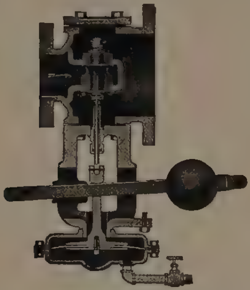
No. 7 Single Sealed Float Valve

Sizes: ¾ to 12 in., inclusive. Bronze bodies in sizes 1½ in. and under, screwed ends only. Iron bodies in sizes 2 in. and above; 2 to 6 in., inclusive, screwed or flanged ends, but screwed ends will be shipped unless specified otherwise; size 8 in., flanged ends only. Sizes 8 in. and under made angle or globe patterns, but angle pattern will be shipped unless specified globe. Sizes 10 and 12 in. made to order, flanged ends, globe pattern only.

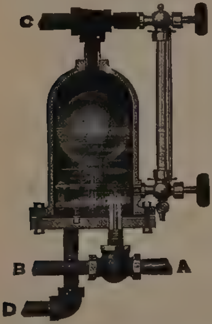
Kieley & Mueller, Inc.

Manufacturers of Specialties for Steam, Water, Air, Oil and Gas

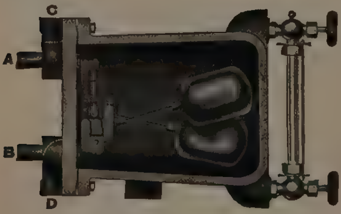
34 West 13th Street **Agents in all Principal Cities** New York City



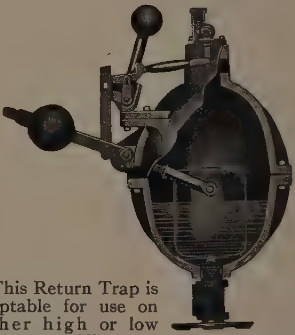
The Kieley Special 98 Reducing Valve is suitable for regulating steam pressure for Vapor and Vacuum Heating. This valve will reduce 100 lb. pressure to a vapor.



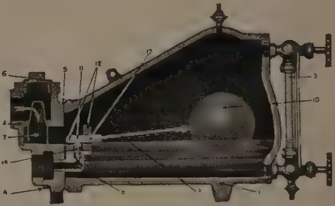
The Rapid Feeder is designed for use in controlling the water supply to heating and industrial boilers. It is a "direct to boiler" feeder and therefore, has extraordinary high capacity.



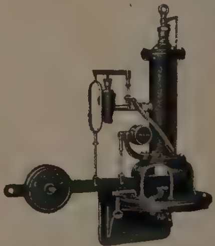
The Duplex Feeder feeds water to the boiler when required and discharges excess water if sluggish returns tend to flood or cause a high water line.



This Return Trap is adaptable for use on either high or low pressures. All parts subject to wear are located externally and easily removable.



Kieley Ball Float Traps have all the desirable features necessary for taking care of High and Low Pressure Condensation. They are compact, easily repaired and have high condensation capacities.

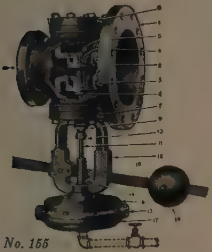


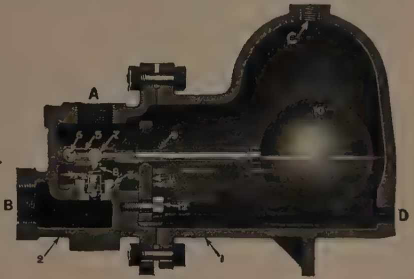
The Climax Junior Damper Regulator. This is a Hydraulic Damper Regulator designed for large heating systems.

The McAlear Mfg. Co.

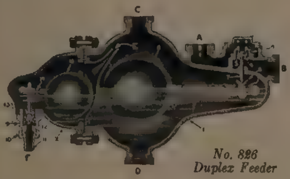
1901-1907 So. Western Avenue **CHICAGO**

Power and Heating Specialties for Controlling Pressures and Flow of Steam, Water, Air or Gas


No. 155



McAlear Reducing Valves are constructed in either the diaphragm weight and lever type, spring weighted diaphragm type or the pilot operated type. They are made with either single or double seats, and with expanded outlets when desired, depending on the type selected. They will reduce steam pressure from 5 to 250 lb. to any desired service pressure from a partial vacuum to 240 lb. Complete information furnished on application. Sizes ⅜ to 20 in.

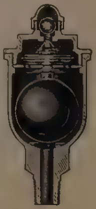


No. 826 Duplex Feeder

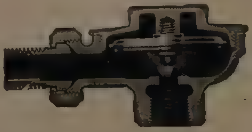
McAlear Direct-to-Boiler Water Feeders are made both Simplex and Duplex and are equipped with Mercoid Switches, when desired, for Oil Burner Control. Working parts of non-corrosive material, heavy seamless copper floats and they feed water direct to the boiler.

McAlear traps are built in both Open Bucket and Ball Float types and are constructed in several different styles to meet any service condition.

No. 717 (illustrated) is invaluable for low pressure drip connections but can be used on pressures up to 125 lb. It has large capacity, equipped with accessible valve construction, deep water seal, and thermostatic element when used for blast trap duty. Sizes ½ to 3 in.



No. 15 Automatic Air Valve is used for relieving mains and risers of low pressure vapor and gravity heating systems. It will operate at any pressure up to 15 lb., and is made in sizes ⅜, ½, ¾ and 1 in.



McAlear Radiator Traps are constructed in several different sizes and patterns. The thermostatic elements are made of the best quality bronze metal, suitable for pressure from a partial vacuum to 15 lb.

The McAlear line of Power, Heating, Gas and Oil Specialties also include: Radiator Hangers, Return Traps, Grease Extractors, Dirt Strainers, Pump Governors, Back Pressure Valves, Water Regulating Valves, Tank Controllers, Gas Regulating Valves, Liquid Level Controllers and many other devices. General Catalogue No. 28 illustrating our complete line, will be gladly furnished upon request.

J. E. Lonergan Co.

211-215 Race Street, **Philadelphia, Pa.**

Branch Offices and Representatives

NEW YORK	C. A. BUTLER, 429 Park Row Bldg.
CHICAGO	NAYLOR-HICKEY CORP., 641 Washington Blvd.
DETROIT	H. O. TRERICE CO., 1338 W. Lafayette Blvd.
ST. LOUIS	MERRITT M. STONE CO., 4459 Manchester Ave.
LOS ANGELES	A. E. GARNJOST, 824 San Fernando Bldg.
LOS ANGELES	JOHN C. BELL CO., 712 E. Sixth Street
SAN FRANCISCO	A. B. AMBLER, 444 Market Street
SEATTLE	P. L. FRANCIS, 900 Dexter Horton Bldg.
PHILADELPHIA (**Southern Representative**)	THOS. H. WINSTON, Suite 313, 1600 Arch Street
Export Office (NEW YORK)	BENJ. WHITTAKER, INC., 114-118 Liberty Street

PRODUCTS

Steam Specialties; Steam Gauges, Pressure and Vacuum; Safety Valves; Water, Oil, Ammonia and Cylinder relief valves.

Also Whistles for Steam or Air, Water Gauges, Oil Cups and Oiling Devices.

Model "GLP"

A.S.M.E., Iron Body, Bronze Mounted

Especially designed for low pressure boilers and converted high pressure boilers.

Can be set to blow off at 10, 15, 20, 25 or 30 lb.

This valve has a high lift and exceedingly high relieving capacity.

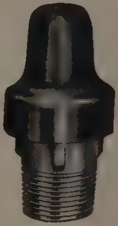
Five sizes—2½ to 4½ in.

Always state Pressure at which valve is to be set.

Model "VAK"

Special Valve for Vacuum Breaking.

Six sizes—½ to 2 in.



Model "HHU"

Pop Safety Valves

A. S. M. E., "House Heating Boiler"

Standard pressures 5, 10 and 15 lb.

Fool proof as Pressure cannot be changed after Valve is set at factory.

Seven sizes—¾ to 3 in.

Portable Boiler Bronze Pop Safety Valves

The Safety Valves illustrated herewith are our Models "KDP" and "ODP" made with high lift and adjustable blow down ring. Made with equalizing top and bottom spring steps, steel spindles, powerful cam lifting lever, outside adjustable blow down ring and complies in every way with the A. S. M. E. code.

Model "KDP"

Pop Safety Valve.

A. S. M. E. Bronze Top Outlet.

Eight Sizes—½ to 3 in.

Model "ODP"

Pop Safety Valve.

A. S. M. E. Bronze Side Outlet.

Eight Sizes—½ to 3 in.

Always state pressure at which valve is to be set.

Model "ORV"

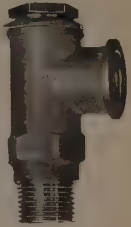
Oil Relief Valve for use on oil burning systems, has large relief and positive in action.

Seven sizes—⅜ to 2 in.

Model "WRV"

Water Relief Valve for tank service.

Three sizes ⅜, ½ and ¾ in.



Model "U"—Relief Valve

"Snifter, Water or Cylinder"—Bronze

A relief valve to be used on cylinders of Steam Engines to prevent a dose of water from blowing off the Cylinder Head.

Furnished with flanged Inlet and Outlet, if desired.

Recommended for Steam Engines, Pumps, Pipe Lines, etc.

In ordering, state pressure at which Valve is to blow off.

Ten sizes—½ to 4 in.

Model "GOZ" Vapor Gauge

A very sensitive gauge graduated to 5 lb. by ounces.

Carefully made and accurately graduated.

An excellent gauge for indicating low pressure.

Two sizes—4½ in. and 5 in. Dial.

Model "BLGW"

Drawn case gauge.

For either pressure or altitude, or combination of both.

Graduation 30 lb., 70 ft.

Two sizes—3½ in. and 4½ in. Dial.

Model "GV"—Vacuum Gauge

Standard single seamless drawn Bourdon tube gauges for vacuum.

Gauges graduated to 30 in. vacuum.

Cocks always furnished without additional charge with all gauges excepting 2½ in. and 3 in. Dial.

Made in cast iron, black Japaned case; also in cast brass polished case.

Ten sizes—2½ to 12 in. Dial.

Model "BLGA"

Pressed steel case gauge for indicating height of water in feet. Graduation 70 ft. All cases rust-proofed prior to enamel.

Three sizes—3½, 4½ and 5 in. Dial.

Model "BLGR"

Drawn case gauge.

Graduated by ounces up to 10 lb., and relayed beyond that point to 30 lb.

For use on house heating boilers.

One size—4½ in. Dial.

Model "BLGB"

Drawn case gauge.

Tank in basement type of gauge for closed heating systems.

Made in two and three-story calibrations only.

One size—3½ in. Dial.

Jas. P. Marsh & Company

FOUNDED IN 1865

2073 Southport Avenue

CHICAGO, ILL.

WASHINGTON OFFICE	LOS ANGELES OFFICE	NEW YORK OFFICE
Bond Building	1220 Maple Avenue	551 Fifth Avenue

Branch Offices and Stocks in Principal Cities

MARSH PRODUCTS

Consists of a complete line of Specialties for heating and industrial purposes which have been accepted as a standard for the past sixty years, gaining its merit through long satisfactory service and sound engineering practice.

Marsh Reflux Traps and Marsh Influx Radiator Valves for vapor or vacuum systems, Heavy Duty Traps, Hvyflo Float Traps, Marsh Boiler Return Traps, Marsh Thermodisk Air Valves, Vents and Air Line Traps for one pipe steam systems, Boiler and Industrial Gauges for all purposes, Thermometers, etc., represents a partial list of the products pioneered by Jas. P. Marsh & Company.

MARSH SERVICE

Marsh Service is at the disposal of Architects, Engineers and Contractors through representatives in over forty cities throughout the United States and Canada.

MARSH VACUUM SYSTEM

Especially suited for large buildings where efficient and economical operation is essential. System comprises of a source of steam supply, steam and return mains, and a mechanical means of maintaining a constant vacuum within the return line system.

Steam is admitted to the radiators through Marsh Influx Radiator Valves and the air and condensation is passed on into the return system through a Marsh Reflux Radiator Trap. The Marsh Hvyflo Float Trap is employed for dripping ends of mains, main risers, etc., and the Marsh Combination Float and Thermostatic Heavy Duty Trap is used on vento and hot water heaters.

MARSH VAPOR SYSTEM

A system designed to meet the requirements of heating apartment buildings, public buildings and residences where the amount of radiation required is not large and it is desired to eliminate the vacuum pump. Piping is simple in design, enabling the system to operate noiselessly and efficiently on pressures as low as eight ounces.

System consists of Marsh Influx Radiator Valves, Marsh Reflux Radiator Traps, Marsh Boiler Return Trap as the means of returning water of condensation back to boiler and the Marsh Air Trap on the return system and Marsh No. 5 Rapid Vent on the supply system as the air expelling mediums.

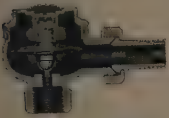
MARSH HI-LO VACUUM SYSTEM

A system designed to operate on pressures at or below atmosphere, having flexible qualities so that the system can be manually or automatically adjusted to correspond to outside temperatures, reducing waste of fuel by overheating. In mild weather an increased vacuum is maintained throughout the system, thereby delivering steam to the radiators at a low temperature, and by means of the Marsh Hi-Lo Traps, the amount of steam in each unit is reduced. In cold weather the vacuum is decreased and temperature of the steam increased, at the same time increasing the amount of steam in each unit to correspond to the amount of heat necessary to maintain a comfortable temperature within the room or space to be heated.

Piping arrangement and pipe sizes are practically identical to that of a standard vacuum system, the only additional features being the Marsh Hi-Lo Governors which maintain a constant differential between supply and return mains under all conditions.

On several prominent installations of this type, one of them the largest co-operative apartment building in the mid-west, a saving of one-third of the total fuel consumption for the heating season was recorded in spite of the fact that this period experienced the severest weather recorded by the U. S. Weather Bureau in that locality for the past forty years. This system is recommended where fuel economy over a long period of years and ease of operation are of great importance. Upon request, complete details and data will be furnished.

Marsh No. 1 Reflux Radiator Trap

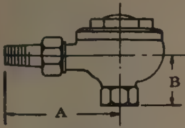


Marsh No. 1 Reflux Radiator Trap

Applicable to radiators, coils or other heating units where a free discharge of air and condensation is desired without passage of steam into the return system. Can also be used as an air line trap on vento or other apparatus where a large volume of air is to be handled.

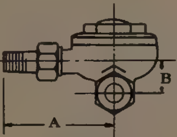
Sturdy in body design as well as interior construction. Diaphragm is of handspun corrugated phosphor bronze with special double seal locking device and a reinforcing ring which will prevent rupture of the diaphragm. Actuated by means of a sensitive combination of volatile fluids. Adjusted and tested at factory. For pressures not to exceed fifteen pounds, but when so specified, can be made for pressures up to and including 100 lb.

Size	Capacity Sq. Ft.	Lbs. Water Per Hour
½"	150	40
¾"	300	75
1"	600	150



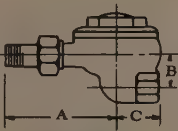
ANGLE

Dimensions		
Size	A	B
½"	3¼"	1½"
¾"	3¼"	1 13/16"
1"	3½"	1⅞"



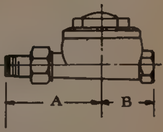
CORNER

Dimensions		
Size	A	B
½"	3¼"	1¼"
¾"	3¼"	1⅝"
1"	3½"	1¾"



BACK OFFSET

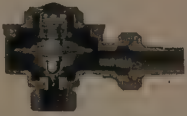
Dimensions			
Size	A	B	C
½"	3¼"	1¼"	1⅛"
¾"	3¼"	1 9/16"	1 7/16"
1"	3½"	1¾"	1⅝"



STRAIGHTWAY

Dimensions		
Size	A	B
½"	3¼"	1¾"
¾"		
1"		

Marsh No. 2 Reflux Radiator Trap

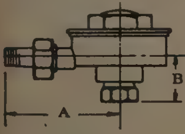


Marsh No. 2 Reflux Radiator Trap

A thermostatic trap capable of handling large volumes of air and condensation. Particularly suited for large radiators, direct-indirect heaters and for dripping downfeed risers and small sub-mains.

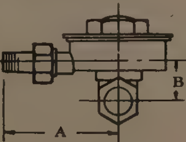
Body is of cast steam brass with heavy nickel plated tailpiece and nut. Diaphragm is of handspun phosphor bronze, having the same internal construction and reinforcement features as the No. 1 Reflux Radiator Trap. Adjusted and tested at factory. For pressures not to exceed fifteen pounds, but when so specified, can be made for pressures up to and including 100 lb.

Size	Capacity Sq. Ft.	Lbs. Water Per Hour
½"	200	50
¾"	500	125
1"	1000	250



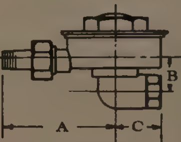
ANGLE

Dimensions		
Size	A	B
½"	3½"	1 7/16"
¾"	3 15/16"	2"
1"	4⅜"	2 1/16"



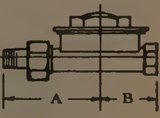
CORNER

Dimensions		
Size	A	B
½"	3¾"	1¼"
¾"	3 15/16"	1⅝"
1"	4 5/16"	1⅞"



BACK OFFSET

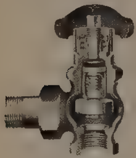
Dimensions			
Size	A	B	C
½"	3⅞"	1¼"	1⅜"
¾"	3 15/16"	1⅝"	1 9/16"
1"	4 5/16"	1⅞"	1⅝"



STRAIGHTWAY

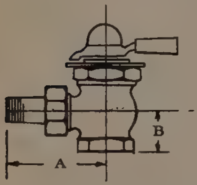
Dimensions		
Size	A	B
½"	3¾"	2"
¾"		
1"		

Marsh Influx Packless Radiator Valve



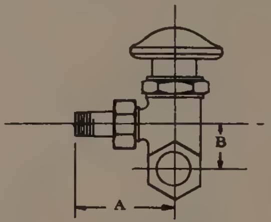
Marsh Influx Radiator Valve

Marsh Influx Packless Radiator Valves are designed for all types and sizes of radiators and coils on steam, vapor and vacuum heating systems. Also furnished for hot water systems when so ordered. Both Packless and Graduated Valves are furnished in oval wheel. Graduated type also in lever handle. The Marsh Graduated Valve is a real modulating valve and by means of setting the indicator at various points on the dial, any desired modulating opening can be obtained. Likewise, by means of a very simple operation the full opening of the valve can be varied on the job. Loosen the lock nut above the graduating dial, turn the graduating dial to desired position and tighten the locknut. The maximum port opening of the valve is then adjusted to desired position.



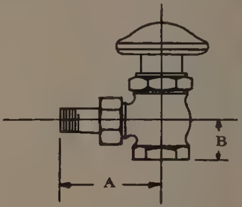
ANGLE GRADUATED

Dimensions		
Size	A	B
½″	2 7/16″	1 3/16″
¾″	2¾″	1 5/16″
1″	3¼″	1 9/16″
1¼″	3½″	1¾″
1½″	3¾″	1 15/16″
2″	4½″	2⅜″



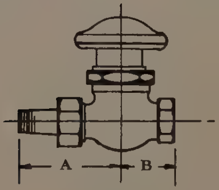
CORNER

Dimensions		
Size	A	B
½″	2⅜″	¾″
¾″	2 13/16″	1⅛″
1″	3 5/16″	1⅛″
1¼″	3½″	1½″
1½″	3⅞″	1 11/16″
2″	4½″	2″



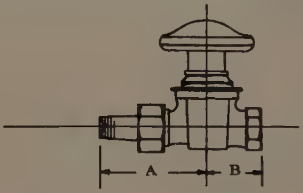
ANGLE

Dimensions		
Size	A	B
½″	2 7/16″	1 3/16″
¾″	2¾″	1 5/16″
1″	3¼″	1 9/16″
1¼″	3½″	1¾″
1½″	3¾″	1 15/16″
2″	4½″	2⅜″



GLOBE

Dimensions		
Size	A	B
½″	2⅜″	1⅜″
¾″	2¾″	1⅜″
1″	3⅛″	1⅝″
1¼″	3 9/16″	1⅞″
1½″	3¾″	1 15/16″
2″	4½″	2½″



GATE

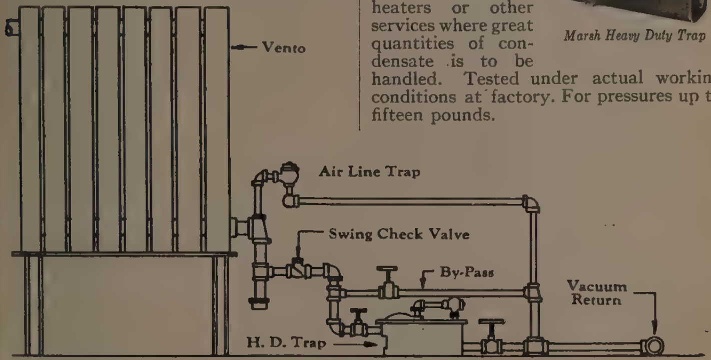
Dimensions		
Size	A	B
½″	2 7/16″	1⅛″
¾″	2 13/16″	1¼″
1″	3 3/16″	1⅜″
1¼″	3½″	1 11/16″
1½″	3⅝″	1¾″
2″	3¾″	1⅞″

Marsh Heavy Duty Trap

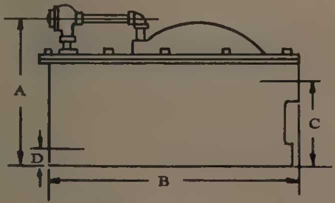
A heavy duty trap of the combined float and thermostatic type for handling large volumes of condensation and air. Has a sturdy cast iron body, a unique float mechanism and a large capacity thermostatic by-pass.

Marsh Heavy Duty Trap

Adaptable for large blast heaters, hot water storage heaters or other services where great quantities of condensate is to be handled. Tested under actual working conditions at factory. For pressures up to fifteen pounds.



Combination Float and Thermostatic Heavy Duty Trap Applied to Vento Heaters



Dimensions				
Size	**A**	**B**	**C**	**D**
1″	13 9/16″	10⅛″	5 5/16″	1½″
1¼″	13 9/16″	10⅛″	5 5/16″	1½″
1½″	15½″	11 1/16″	5 11/16″	1⅝″
2″	15½″	11 1/16″	5 11/16″	1⅝″

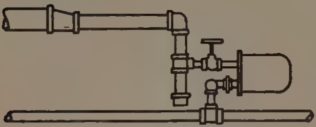
Capacity in Pounds Water Per Hour						
Size	**½#**	**1#**	**2#**	**3#**	**4#**	**5#**
1″	1800#	3150#	4442#	5284#	6249#	6955#
1¼″	2620#	4345#	6125#	7435#	8613#	9576#
1½″	3327#	5676#	8024#	9778#	11286#	12517#
2″	4239#	7197#	12303#	14256#	15823#	22228#

Marsh Hvyflo Float Trap

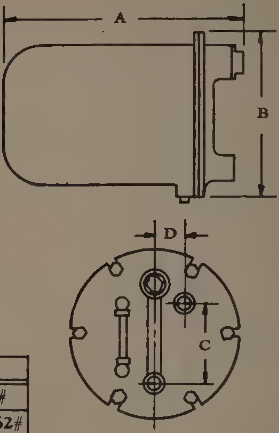
Marsh Hvyflo Float Trap

A light weight combined float and thermostatic trap for handling large amounts of condensation and air, and can be suspended directly from piping without additional support. For use on all drip points, main risers, unit heaters and indirect heaters.

Has a heavy copper float and compound float mechanism of non-corrosive metals. Outlet orifice is always water sealed, presenting no opportunity for steam leakage and air is handled through thermostatic by-pass. Can be equipped with gauge glass feature when so ordered. Tested under actual working conditions at factory. For pressures up to fifteen pounds.



Hvyflo Trap Dripping End of Main

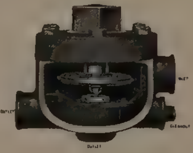


Dimensions			
A	B	C	D
10½"	7¾"	4"	$1\frac{11}{16}$"

Capacity in Pounds of Water Per Hour					
½#	1#	2#	3#	4#	5#
420#	900#	1227#	1467#	1690#	1862#

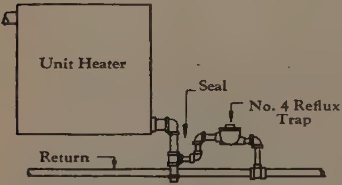
Marsh No. 4 Reflux Drip Trap

A large capacity thermostatic drip trap designed to meet the requirements of those who prefer a thermostatic trap for dripping ends of mains, large risers, unit heaters and small indirect heating units.

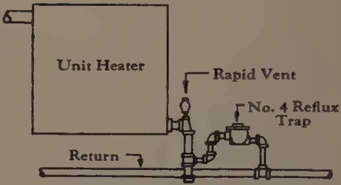


Marsh No. 4 Reflux Drip Trap

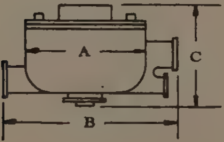
Body is of heavy cast iron with bolted cover and cleanout opening. Fitted with a heavy handspun phosphor bronze diaphragm of the double seal lock type having ample internal reinforcement. Seat is of brass. Suitable for pressures up to fifteen pounds, or for pressures up to 100 lb. when so specified.



No. 4 Reflux Trap Applied to A Vacuum System. Note Seal



No. 4 Reflux Trap Applied to A Gravity or Vapor System

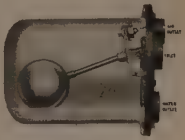


Dimensions				Capacities	
Size	A	B	C	½# Press.	1# Press.
¾"	5"	6½"	5¾"	475#	950#
1"	5½"	7"	6"	750#	1500#
1¼"	6"	7½"	6¾"	1050#	2100#

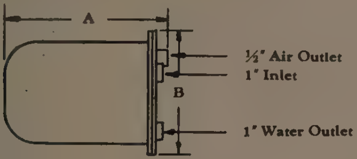
Marsh Air Trap

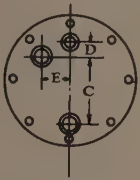
A light weight air vent trap for use on vapor systems, having a large air outlet that permits rapid expulsion of air from the return system. Float mechanism is so arranged that it is impossible for water to come out of air outlet should it reach this point.

Equipped with a copper float, brass mechanism and post and a Jenkins composition seat on the air outlet. Made in one inch size only, with one-half inch air outlet.



Marsh Air Trap





Dimensions				
A	B	C	D	E
9 3/16"	7¾"	3¼"	1 3/16"	1 13/16"

Capacities						
Pounds Pressure	½#	1#	2#	3#	4#	5#
Cu. Ft. Air per minute	1	3	6	8	10	12
Capacity in Sq. Feet	2000	6000	12,000	16,000	20,000	24,000

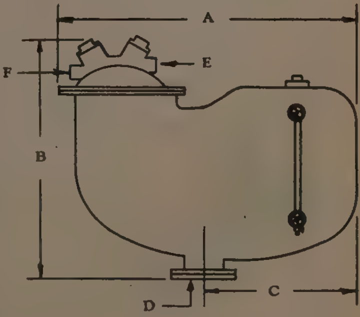
Marsh Automatic Boiler Return Traps

Marsh Boiler Return Trap

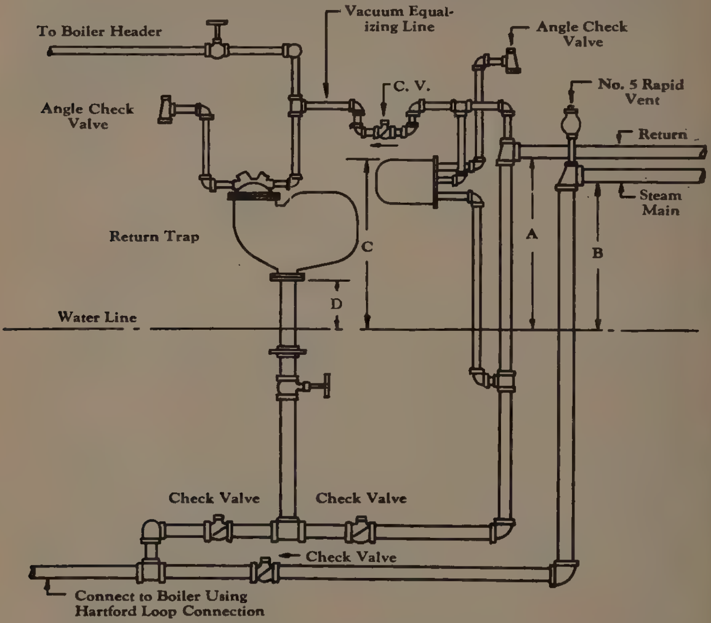
Can be installed on any vapor heating system with a minimum of head room above the boiler water line as will be noted from the installation diagram and dimensions. Will automatically return all water of condensation to the boiler promptly and practically noiselessly, maintaining constant water line in the boiler.

The trap is very simple in construction consisting of a ball float, which, through a lever arm throws a counterweight which in turn operates the piston-like stems opening and closing the ball valves which operate within the combination strainer guides. There are no springs, sliding mechanisms, complicated adjustments and all mechanism is enclosed within the trap. Like other Marsh heating specialties, the Marsh Boiler Return Trap is guaranteed for five years continuous satisfactory operation.

Dimensions						
Sq. Ft.	A	B	C	D	E	F
2000 4000	17½"	17¼"	9 5/16"	2"	¾"	½"
6000 8000 10000	21"	21¼"	11½"	2½"	¾"	½"



PIPING ARRANGEMENT OF THE MARSH BOILER RETURN TRAP AND AIR TRAP AS INSTALLED ON THE MARSH VAPOR SYSTEM



Dimensions				
Size Trap	A	B	C	D
2000 4000	25″	24″	25″	6″
6000 8000 10000	30″	29″	30″	6″

The above are minimum dimensions

Marsh No. 5 Thermodisk Rapid Vent

Marsh No. 5 Rapid Vent

A reliable air eliminating device for the ends of steam mains on vapor or one pipe steam systems. This vent has a sturdy brass body and equipped with a large brass float, thermostatic member and an air port of sufficient size to permit rapid expulsion of air from the system. Also equipped with vacuum top. Made in sizes from ¼ up to ¾ in.

Marsh No. 7 Air Eliminator

Marsh No. 7 Air Eliminator

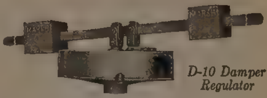
This air vent is also used on the return system of Marsh Vapor Systems as the air expelling medium in lieu of the Marsh Air Trap. Has a polished brass body with a female bottom connection. Will allow free passage of air but will close off instantly should water reach this point. Equipped with a vacuum top feature. Made in ¾ and 1 in. sizes.

Marsh Compound Retard Gauge

Marsh Compound Retard Gauge

A compound gauge designed expressly for vapor systems, having a sensitive spring that will register the slightest change in pressure. Dial is graduated in ounces up to five pounds, and in five pound graduations from five to thirty pounds. Depth of vacuum is clearly indicated in wide half-inch graduations up to 10 in., and in five inch graduations from 10 in. to 30 in. vacuum.

Damper Regulator

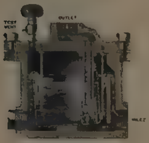


D-10 Damper Regulator

To obtain the most economical results from a vapor system, a damper regulator that will open or close draft or check dampers with the slightest change in pressures is essential.

The Type D-10 Damper Regulator is equipped with a sensitive ten inch flexible metal bellows that will actuate at the slightest change in pressure. Has a 48 in. lever with weights and bell cranks. Made in one inch female bottom connection only. Can also be furnished in other size diaphragms if so ordered.

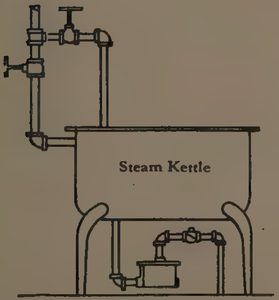
Marsh Medium Pressure Steam Trap



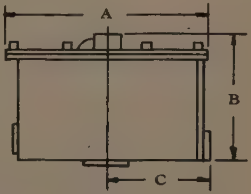
Marsh Medium Pressure Trap

A medium pressure trap of the open float type for dripping steam lines, drying, cooking, refining and other industrial apparatus where the steam pressure does not exceed 100 lb.

Has a heavy cast iron body with bolted cover, non-collapsible copper open float with valve post rigidly attached. Valve seat is of a special hard metal which prevents wiredrawing. Also equipped with cleanout feature and test vent. Adjusted and tested at factory for all varying pressures up to 100 lb.



Medium Pressure Trap Applied to Cooking Apparatus



Dimensions				Llbs. Water Per Hour at 75# Pressure
Size	A	B	C	
¾"	6⅛"	5⅝"	2¾"	500
1"	6¾"	6⅛"	3⅛"	750
1¼"	7¾"	6¾"	4"	1500
1½"	8½"	7"	4½"	3000

SPECIFICATION FOR A MARSH VACUUM SYSTEM

1. GENERAL CONDITIONS.—The general conditions governing this portion of the work shall be in accordance with those of the American Institute of Architects.

2. SCOPE OF WORK.—The work to be done includes the furnishing of all labor and materials for the complete erection of a Marsh Vacuum Heating System as hereinafter specified and as shown on drawings. Work to be done shall be executed in a neat and workmanlike manner, and all heating apparatus pertaining to this portion of the work to be of the best grade materials and shall strictly conform to these specifications.

3. BOILER.—Furnish and install a..........type boiler as manufactured by...................., having a guaranteed rating of..........sq. ft. of radiation. Boiler shall be equipped with all necessary trimmings and accessories, including Marsh Compound Vacuum and Pressure Gauge, Kunkle Pop Safety Valve and Type D-10 Damper Regulator.

The above boiler shall be connected to chimney with a ....in. breeching of..........gauge black steel, all as shown on plans.

4. PIPE AND FITTINGS.—Contractor shall furnish and install where indicated on plans all pipe and fittings properly supported and graded to insure a complete and successful operation of the system. Fittings to be of standard best grade cast iron, and pipe to be of mild black steel properly threaded and reamed. Joints to be made up with a paste consisting of Portland cement and boiled linseed oil applied to male threads only. Proper provision to be made for expansion in all mains, risers and branches.

Boiler headers shall be made up of standard flanged fittings connected to boiler full size of steam opening, same to be dripped to return header through a bleeder. All spring pieces to steam and return mains shall be taken out of top of mains at 45 deg. on upfeed systems, and out of bottom of steam mains at 45 deg. on downfeed systems. All runouts or branches to radiators or risers to be graded 1 in. in 10 ft. and supply and return mains 1 in. in 20 ft.

Ends of mains and points where mains rise to a higher level shall be dripped through a Marsh....................Trap as indicated on plans. Each drip point to be provided with a dirt strainer or a scale pocket. All drip traps to be properly valved. Return mains shall be graded to permit condensation to flow to pump suction strainer by gravity. Lifts in return mains are not to be used except where unavoidable, and in such cases, lift shall occur at pump, not to exceed 2 ft. below suction strainer.

5. COVERING.—All steam mains, risers and runouts that are exposed shall be covered with an approved air cell covering 1 in. thick, same to be canvased and banded in a neat and workmanlike manner. Fittings to be covered with plastic asbestos cement trowled smooth and canvased. System shall be tested with water for leaks before covering of piping is commenced.

6. FLOOR PLATES.—Where pipes project through finished floor, ceiling or wall, provide an approved type nickel plated floor or ceiling plate.

7. RADIATION.—Furnish and install where shown on plans a total of..........sq. ft. of direct radiation, as manufactured by....................or equal, to have top supply and bottom return tappings at opposite ends. Contractor must instruct manufacturer to thoroughly wash sections free of all core sand and plug all openings. Eccentric bushings shall be used at return tapping.

8. PAINTING.—All radiation and exposed piping shall be given one priming coat of flat paint and one coat of paint to match surrounding decorations, except where piping is to be covered, all as directed by the Architect. Boiler and smoke breeching to be given two coats of graphite paint.

9. RADIATOR TRAPS.—At the return end of each radiator, install a Marsh Reflux Radiator Trap, size to be determined by the schedule below.

10. RADIATOR VALVES.—On the supply end of each radiator, install a Marsh Influx Radiator Valve,.................... (Packless, Oval Wheel Graduated, Lever Handle Graduated) type, of a size to be determined by the schedule below.

TAPPING SCHEDULE

Sq. Ft.	Valve	Trap
0–30	½″	½″ No. 1
31–80	¾″	½″ No. 1
81–125	1″	½″ No. 1
126–175	1¼″	½″ No. 2
176–250	1½″	½″ No. 2
250 up	2″	¾″ No. 2

11. VACUUM PUMP.—Furnish and install where shown a ....(Duplex or Single unit) vacuum pump having a guaranteed condensate and air capacity equivalent to ....sq. ft. of direct radiation, as manufactured by .... Motor to be wound for..........phase,.......... cycle,..........volt.......... (A.C. or D.C.) current. Pump shall be properly valved and bypassed in accordance with insurance and manufacturers regulations. Pump shall be fitted with one Marsh Compound Gauge and one Thermometer.

12. CLEANING SYSTEM.—System shall be operated for a period of several days with condensation wasted to sewer. Boiler shall then be blowed down through the bottom blowoff connection under 5 lb. pressure. Remove safety valve and connect piping from this opening to sewer properly valved. Fill boiler to proper water level, built hot fire to create at least 5 lb. pressure and open valve in top blowoff connection, feeding enough water to boiler to maintain a constant water level. After four hours firing in this manner, fill boiler with water and allow hot water to flow out of top blowoff connection for one hour. Draw the fire, shut off feed water and blow down through bottom blowoff connection. Allow boiler to cool, replace safety valve and fill boiler with fresh water to proper level.

13. GUARANTEE.—The contractor shall guarantee in the entire system a complete, continuous and noiseless circulation of steam to each radiator or coil, free of all air and condensation, at a pressure not to exceed.......... lb. gage. He shall also hold himself responsible for any defects which may develop in any part of the system, including piping, valves or other apparatus included in this specification, due to faulty workmanship, design or material at any time within.......... years from date of final payment, and shall remedy such defects at his own cost.

14. FINALLY.—The true intent of these specifications is to bring about the satisfactory completion of the system as outlined above, and nothing contained herein can be construed to relieve the contractor from making good and perfect the work in all usual details of construction, and he will be held responsible and bear all expenses incidental to the satisfactory completion of the work.

SPECIFICATION FOR A MARSH VAPOR SYSTEM

1. GENERAL CONDITIONS.—The general conditions governing this portion of the work shall be in accordance with those of the American Institute of Architects.

2. SCOPE OF WORK.—The work to be done includes the furnishing of all labor and materials for the complete erection of a Marsh Vapor Heating System as hereinafter specified and as shown on drawings. Work to be done shall be executed in a neat and workmanlike manner, and all heating apparatus pertaining to this portion of the work to be of the best grade materials and shall strictly conform to these specifications.

3. BOILER.—Furnish and install a....................type boiler as manufactured by..................., having a guaranteed rating of............sq. ft. of radiation. Boiler shall be equipped with all necessary trimmings and accessories, including Marsh Compound Vacuum and Pressure Gauge, Kunkle Pop Safety Valve and Type D-10 Damper Regulator.

The above boiler shall be connected to chimney with a ....in. breeching of..........gauge black steel, all as shown on plans.

4. PIPE AND FITTINGS.—Contractor shall furnish and install where indicated on plans all pipe and fittings properly supported and graded to insure a complete and successful operation of the system. Fittings to be of standard best grade cast iron, and pipe to be of mild black steel properly threaded and reamed. Joints to be made up with a paste consisting of Portland cement and boiled linseed oil applied to male threads only. Proper provision to be made for expansion in all mains, risers and branches.

Boiler header shall be made up of standard flanged fittings connected to boiler full size of steam opening, same to be dripped to return header through a bleeder. All spring pieces to steam and return mains shall be taken out of top of mains at 45 deg. on upfeed systems, and out of bottom of steam mains at 45 deg. on downfeed systems. All runouts or branches to radiators or risers to be graded 1 in. in 10 ft and supply and return mains 1 in. in 20 ft.

Short run steam mains shall be returned back to boiler at a height not less than 24 in. above water line, dropping to return header with check valve and vented through a Marsh No. 5 Thermodisk Rapid Vent. Mains that terminate a great distance from boiler shall be dripped through a Marsh ....trap and vented by a Marsh No. 5 Thermodisk Rapid Vent. Return mains shall run in same direction as steam mains and shall terminate at the boiler at a height not less than............in. above water line.

5. COVERING.—All steam mains, risers and runouts that are exposed shall be covered with an approved air cell covering 1 in. thick, same to be canvased and banded in a neat and workmanlike manner. Fittings to be covered with plastic asbestos cement trowled smooth and canvased. System shall be tested with water for leaks before covering of piping is commenced.

6. FLOOR PLATES.—Where pipes project through finished floor, ceiling or wall, provide an approved type nickel plated floor or ceiling plate.

7. RADIATOR.—Furnish and install where shown on plans a total of..........sq. ft. of direct radiation, as manufactured by........................or equal, to have top supply and bottom return tappings at opposite ends. Contractor must instruct manufacturer to thoroughly wash sections free of all core sand and plug all openings. Eccentric bushings shall be used at return tapping.

8. PAINTING.—All radiation and exposed piping shall be given one priming coat of flat paint and one coat of paint to match surrounding decorations, except where piping is to be covered, all as directed by the Architect. Boiler and smoke breeching to be given two coats of graphite paint.

9. RADIATOR TRAPS.—At the return end of each radiator install a Marsh Reflux Radiator Trap, size to be determined by the schedule below.

10. RADIATOR VALVES.—On the supply end of each radiator install a Marsh Influx Radiator Valve,...... . ... (Packless, Oval Wheel Graduated, Lever Handle Graduated) type, of a size to be determined by the schedule below.

TAPPING SCHEDULE

Sq. Ft.	Valve	Trap
0– 30	½"	½" No. 1
31– 80	¾"	½" No. 1
81–125	1"	½" No. 1
126–175	1¼"	½" No. 2
176–250	1½"	½" No. 2
250 up	2"	¾" No. 2

11. VAPOR SPECIALTIES.—At each point where steam mains drop to a lower level or where a steam main is dripped, it shall be vented by a Marsh No. 5 Thermodisk Rapid Vent. Where the return main drops below water line at boiler, it shall be vented by a Marsh Air Trap as indicated on drawings. Return main shall be connected to a Marsh Boiler Return Trap, having a capacity of..........sq. ft. of direct radiation. Install swing check valves on each side of return trap connection in return main and connect same to boiler header bleeder through Hartford loop connection 3 in. below water line of boiler. All check valves to be tested for tightness before installing. Install vacuum equalizing line between supply and return mains with swing check valve closing on pressure on supply system.

12. CLEANING SYSTEM.—System shall be operated for a period of several days with condensation wasted to sewer. Boiler shall then be blowed down through the bottom blowoff connection under 5 lb. pressure. Remove safety valve and connect piping from this opening to sewer properly valved. Fill boiler to proper water level, build hot fire to create at least 5 lb. pressure and open valve in top blowoff connection, feeding enough water to boiler to maintain a constant water level. After four hours firing in this manner, fill boiler with water and allow hot water to flow out of top blowoff connection for one hour. Draw the fire, shut off feed water and blow down through bottom blowoff connection. Allow boiler to cool, replace safety valve and fill boiler with fresh water to proper level.

13. GUARANTEE.—The contractor shall guarantee in the entire system a complete continuous and noiseless circulation of steam to each radiator or coil, free of all air and condensation, at a pressure not to exceed..... . .....lb. gage. He shall also hold himself responsible for any defects which may develop in any part of the system, including piping, valves or other apparatus included in this specification, due to faulty workmanship, design or material at any time within.......... years from date of final payment and shall remedy such defects at his own cost.

14. FINALLY.—The true intent of these specifications is to bring about the satisfactory completion of the system as outlined above, and nothing contained herein can be construed to relieve the contractor from making good and perfect the work in all usual details of construction, and he will be held responsible and bear all expenses incidental to the satisfactory completion of the work.

Marsh Gauges and Industrial Instruments

Our experience of over sixty years in designing and manufacturing the full and complete line of Marsh Gauges enables us to produce any size or style of Gauge required for any particular service or industry.

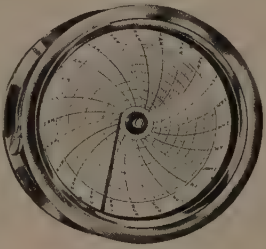
All Marsh Gauges are accurately graduated by open mercury column, adjusted, tested and warranted correct before leaving the factory. Our Catalog No. 52-G showing a complete line of Gauges will prove beneficial to the Architect and Engineer, a few excerpts of which are illustrated on the following page.

Marsh Standard Pressure Gauges

Marsh Pressure Gauge

Marsh Gauges are adaptable for use on steam, water, gas or any pressure medium which will not deteriorate brass. These gauges are available in a wide variety of dial graduations in sizes 2 in. to 16 in. Furnished in bottom connection for pipe lines and back connection for instrument panels.

Marsh Recording Gauges



Marsh Recording Gauge

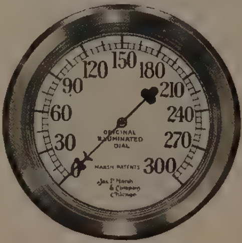
In round form to match indicating instruments on gauge board panels and fitted with hinged door, lock and key. Twenty-four hour record and available in a large range of pressure charts. Also compound pressure and vacuum. Sizes from 6¾ in., 8½ in., 10 in. and 12 in. Also available in a combination instrument both indicating and recording.

Marsh Clocks

Marsh Clock

Especially designed for use in stationary and marine engine rooms. Also on gauge board panels. Mounted in casings to match other instruments on gauge board panels, with hinged door, lock and key. Furnished in sizes 6¾ in. to 16 in., inclusive.

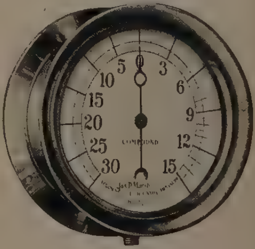
Marsh Illuminated Dial Gauges



Marsh Illuminated Dial Gauge

So constructed with non-breakable glass dial and glass back that with electric light bulb hung behind, all graduations, numerals and indicating hand stand out clearly in silhouette. With electric light turned off, hand and graduations show up black against the white background.

Marsh Compound Gauges



Marsh Compound Gauge

For both piping and gauge board panels to match the other indicating gauges. Made in bottom connection and back connection to indicate both pressure and vacuum on such services as heating supply, return line, etc.

Marsh Flush Mounted Instruments

Marsh Flush Mounted Gauge

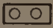
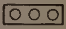
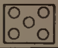
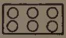
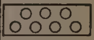
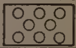
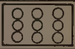
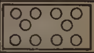
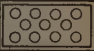
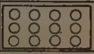
The complete line of Marsh Indicating and Recording instruments is produced also in flush mounted construction per the illustration. Available in sizes 8½ in., 10 in. and 12 in. Also available in the illuminated dial construction so that electric lights can be hung in the back of the board and eliminate the glare of direct lighting.

Marsh Gauge Board Panels

The sketch below shows a number of typical examples of instruments and gauge board panels, with the over-all dimensions of same for convenience in locating the panels. Also shown are the overall dimensions of all sizes of Marsh Instruments for convenience in laying out gauge board panels where it is desired to have some combination not shown or a panel to have more than one size of instruments thereon.

Marsh Indicating Instruments, recording instruments, clocks, etc., are available in all of the standard sizes and are furnished in black finish all over or brass trim, nickel trim or polished brass, nickel plated or chrome finish all over. Marsh Gauge Boards are produced in marble, slate, wood, steel, etc. Bulletins Nos. 1, 2, 15 and 21 describe Marsh instruments and Marsh Gauge Board Panels in great detail.

TYPICAL LAYOUTS OF MARSH GAUGE BOARDS AND OVERALL DIMENSIONS OF MARSH GAUGES

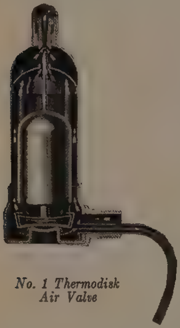
OutsideDiam.	6½"	7⅝"	8 7/16"	10 1/16"	11 13/16"	14"	Outside Diam.
Size of Dial	5"	6"	6¾"	8½"	10"	12"	Layout
Size of Board	12"x12"x1"	13"x13"x1"	14"x14"x1"	16"x16"x1"	18"x18"x1"	21"x21"x1"	
Size of Board	21"x12"x1"	24"x13"x1"	26"x14"x1"	29"x16"x1"	33"x18"x1¼"	39"x21"x1¼"	
Size of Board	30"x12"x1"	34"x13"x1"	37"x14"x1¼"	42"x16"x1¼"	43"x18"x1¼"	57"x21"x1½"	
Size of Board	21"x21"x1"	24"x24"x1"	26"x26"x1¼"	29"x29"x1¼"	33"x33"x1¼"	39"x39"x1½"	
Size of Board	25"x25"x1¼"	28"x28"x1¼"	30"x30"x1¼"	34"x34"x1¼"	39"x39"x1½"	47"x47"x1½"	
Size of Board	30"x21"x1¼"	34"x24"x1¼"	37"x26"x1¼"	42"x29"x1½"	48"x33"x1½"	57"x39"x1½"	
Size of Board	39"x20"x1¼"	45"x22"x1¼"	48"x24"x1¼"	55"x27"x1½"	63"x31"x1½"	76"x39"x1½"	
Size of Board	30"x28"x1¼"	34"x31"x1¼"	37"x34"x1½"	42"x38"x1½"	48"x44"x1½"	57"x53"x1½"	
Size of Board	30"x30"x1¼"	34"x34"x1¼"	37"x37"x1½"	42"x42"x1½"	48"x48"x1½"	57"x57"x1½"	
Size of Board	39"x28"x1¼"	45"x31"x1½"	48"x34"x1½"	55"x38"x1½"	63"x44"x1½"	38"x53"x1½" Two Panels	
Size of Board	39"x28"x1¼"	45"x31"x1½"	48"x34"x1½"	55"x38"x1½"	63"x44"x1½"	38"x53"x1½" Two Panels	
Size of Board	39"x30"x1¼"	45"x34"x1½"	50"x37"x1½"	55"x42"x1½"	63"x48"x1½"	38"x57"x1½" Two Panels	

TYPICAL EXAMPLES OF MARSH GAUGE BOARDS

MARSH THERMODISK AUTOMATIC AIR VALVES AND VENTS

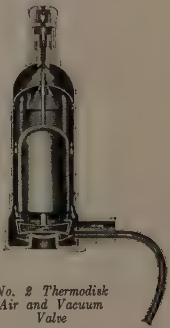
The Marsh Thermodisk line of Automatic Air Valves and Vents, including the Marsh No. 5 Thermodisk Rapid Vent and the Marsh No. 7 Air Eliminator shown among Marsh Vapor Specialties, includes an air valve or vent for every air eliminating purpose on gravity steam heating systems, one pipe gravity vacuum systems, air line systems and vapor heating systems. Each Marsh Thermodisk valve and Vent is the highest grade obtainable in its particular type. All Marsh Thermodisk Valves and Vents are guaranteed for five years to function perfectly and give excellent satisfaction.

Marsh No. 1 Thermodisk Syphon Automatic Air Valve


No. 1 Thermodisk Air Valve

As installed upon any radiator, large or small, will vent the air rapidly due to the large capacity which has been built into this valve and will keep the radiator constantly free of air. Will not leak water or steam, or hiss and is absolutely noiseless in operation. Made also in straight shank pattern.

Marsh No. 2 Thermodisk Syphon Air and Vacuum Valve


No. 2 Thermodisk Air and Vacuum Valve

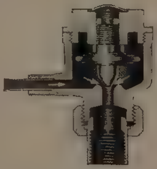
With the installation of the Marsh No. 2 Thermodisk Syphon Air and Vacuum Valve on the radiators, Marsh Vents on the supply, any tight one pipe gravity steam heating job can be made into a one pipe gravity vacuum heating system. This valve together with the vents eliminates the air from the system, keeps it out and when the fire is banked, will hold vacuum so as to retain heat in the radiator many hours after. In the morning, circulation of steam to radiators is prompt and efficient. Made also in straight shank pattern.

Marval Syphon Automatic Air Valve

A medium priced high grade syphon automatic air valve. Like the Marsh Thermodisk, it is all metal, guaranteed to give excellent satisfaction and noiseless in operation. The valve is smaller in size and capacity than the Marsh Thermodisk Syphon Automatic Air Valve, but in its class will vent the radiator rapidly and maintain the radiator efficiently. Made also in straight shank pattern.

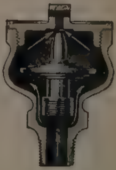
Marval Syphon Air Valve

Marsh No. 3 Thermodisk Air Line Valve


Marsh No. 3 Air Line Valve

For installation on Paul and similar air line heating systems, vento, etc. Made in a wide range of sizes. Passes all air promptly but leaks no steam or vapor. Operates perfectly with or without mechanical suction.

Marsh No. 6 Thermodisk Quick Vent


Marsh No. 6 Quick Vent

For installation at any high point where a large volume of air is to be rapidly vented or where there is no danger of water leak. This valve passes air at all temperatures and closes promptly against steam.

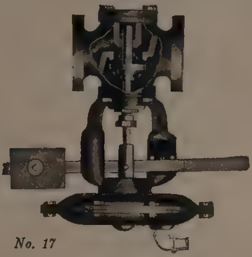
Mueller Steam Specialty Co., Inc.

349-351 West 26th Street, New York City

Steam, Water, Air, Oil and Gas Specialties for Heating and Power Plants

Pressure Reducing Valves—Straight Pattern and With Increased Outlet

No. 11


No. 17

No. 21

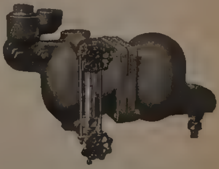
No. 11—For Vacuum, Vapor and Low Pressure Heating Systems. Initial Pressures, up to 200 lb.; Reduced Pressures, 0 to 10 lb.

No. 17 and 21—For automatic control of reduced pressures on dead-end service, requiring a tight closing valve, such as tank heaters, kitchen utensils, sterilizing apparatus, laundry equipment, kettles, cookers, driers, etc. Initial Pressures up to 200 lb. Reduced Pressures 0 to 150 lb.

Constructed with full globe bodies. Center guide eliminates the wings on discs, and increases efficiency, assures minimum noise and prolongs the life of the seats and discs. Lever and weight operates on a steel roller bolt, assuring a most sensitive valve. Spring type furnished with special long springs for sensitive operation and wide ranges of reduced pressures.

No. 501 Junior up to 5000 Sq. Ft.

No. 507 Up to 22,500 Sq. Ft.
No. 511 for Industrial Service

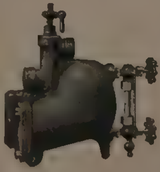

No. 517 Duplex up to 22,500 Sq. Ft.

Automatic Water Feeders with a powerful leverage to control the water line in steam boilers, etc. They supply make up water to compensate for evaporation, leaks, steam utilized in process work and condensation wasted. Where condensation held up in the system eventually returns in large quantities, our Duplex type protects the boiler against flooding. All working parts of non-corrosive metal, are accessible without breaking pipe connections. Provided with an integral strainer. For steam pressures up to 100 lb., water pressures up to 120 lb.

No. 315 up to 25 lb. Pressure
No. 317 up to 150 lb. Pressure

Simple, Positive and Compact Air Eliminators and Return Steam Traps for returning the condensation from any type of low or high pressure heating system or apparatus, direct to boiler at high temperatures and discharging the air to the atmosphere.

No.	Inlet	Outlet	Steam	Vent	Sq. Ft. Rad.
1	3/4	1	3/4	1/2	2250
2	1	1 1/4	3/4	1/2	3300
3	1 1/4	1 1/2	1	3/4	4950
4	1 1/2	2	1	3/4	7200
5	2	2 1/2	1 1/4	1	9000
6	2 1/2	2 1/2	1 1/4	1	14,400


No. 219 up to 30 lb. Pressure
No. 221 up to 150 lb. Pressure

Simple, Sturdy and Compact Steam Traps for draining water of condensation from steam apparatus and steam mains.

Powerful compound leverage enables them to take care of large quantities of condensation.

Equipped with strainer, water gages, air cock, blow-off and integral by-pass valve, when desired.

All working parts accessible without disturbing any pipes.

Valves sealed with several inches of water, making the escape of steam impossible.

Made in sizes from ½ to 3 in.

Catalogue and Bulletins covering our Complete Line gladly furnished on application.

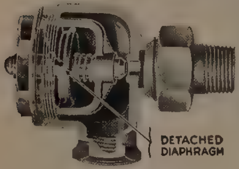
TRADE
MONASH
MARK

Monash-Younker Co., Inc.

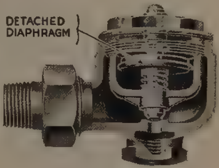
ESTABLISHED 38 YEARS

CHICAGO NEW YORK

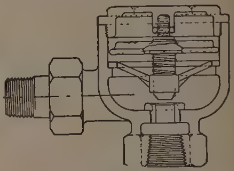
MONASH THERMOSTATIC RETURN LINE TRAPS



No. 35-A-½ in.
Made in Angle only.



No. 35-B-½ in.
Made in Angle, Right, Left and Straightway.



No. 36-B
Made in Angle only.

The working parts or "ELEMENT" of MONASH Thermostatic line of Traps are described on following page.

Designed to overcome the various faults of ordinary return line traps, the MONASH have proven their efficiency in rigid tests in actual operation over a period of *Thirteen Years* in many large buildings.

When MONASH Traps are specified the responsibility of the heating engineer ceases because they are *Guaranteed in Writing for Ten Years*—for pressure not to exceed Ten (10) lbs.

The No. 35 Trap can be furnished with either a vertical or horizontal seat as illustrated above.

No. 35 A or B	½ in.	200 sq. ft.	65 lbs. water per hour
No. 36 B	½ in.	350 sq. ft.	108 lbs. water per hour
No. 36 B	¾ in.	590 sq. ft.	160 lbs. water per hour
No. 36 BX	¾ in.	800 sq. ft.	280 lbs. water per hour

Monash Thermostatic Heavy Duty or Drip Traps for 25 lbs. Pressure

MONASH thermostatic special heavy duty or drip traps are made with **dirt-pocket, clean-out** and **by-pass.** Vertical seat and diaphragm outside the steam chamber. Especially suitable for **blast coils, dry kiln coils, main drips, dryers, laundry machinery** and all points where large quantities of condensation is to be handled.

No.	40	42	44
Size . . . inches	½	¾	1
Sq. Ft. of Radiation	350	1500	4000
Water per Hour . . . pounds	108	475	1250
Net Weight . . . pounds	3.25	5.00	7.50

Monash Guaranteed Automatic Air Valves

No. 1

MONASH No. 1, all metal, non-adjustable automatic air valve in which the base and nipple are in one casting—no soldered or sweated joints to come apart.

MONASH No. 6, four-way-drain, lock-shield, automatic air valve with all working parts above opening to radiator. Self-cleaning; no flooding of floors and other damage.

No. 6

Specify MONASH Valve holder with valve.

Monash Quick Venting Valves

No. 27

For mains and risers the MONASH No. 27 thermostatic quick venting valve is desirable. Has heavy brass body and cover, phosphor bronze thermostatic diaphragm.

Operates automatically at all pressures up to 10 lb.

Insures rapid steam circulation. Closes against steam, but does not close against water.

Connections are ⅜ in., 1 lb. net weight.

Monash Thermostatic Air Line Valves

for drip or air line systems; also for venting vento stacks and blast coils.

Is rapid in action and positive in results, passing all air but closing tightly against steam.

Made of brass, white plated; the No. 2 is ⅛ x ¼ in., the No. 3 is ¼ x ⅜ in. 1 lb. net weight.

No. 2

A WORD TO HEATING AND VENTILATING ENGINEERS

Obsolete and defective Return Line Radiator Traps can be reconstructed and made BETTER THAN NEW by inserting the MONASH THERMOSTATIC TYPE "C" ELEMENT into the old Trap Bodies.

Have your client send us an old (half-inch) Radiator Trap complete with nut and tail piece attached and if it has a screwed-in seat, we will replace it with *our own* seat and insert our MONASH Thermostatic Type "C" Element into the Trap Body and return it to *your* client for test on consignment, postpaid.

This MONASH Element consists of a Diaphragm, which is the heart of the Trap, and the construction of same is illustrated and described herewith below.

If the Trap, sent us by your client, is one that we cannot reconstruct, then we will gladly furnish a *MONASH Ten Year Guaranteed Trap Complete* with the proper length tail piece so that it will fit into the roughing-in dimensions of the old Trap and no pipe fitting need be done. **This will give you an opportunity to learn first hand all about the virtues of the MONASH Element in the old Trap Body or the MONASH Trap complete.**

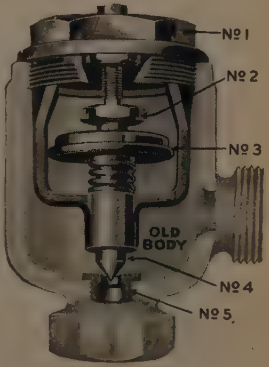
We feel confident that once you know more about the MONASH Product you may want to specify it in your work.

MONASH THERMOSTATIC DIAPHRAGM

This Diaphragm is as sensitive to the various changes of temperature as the most delicate instrument, yet, so sturdy in construction that we do not hesitate to *Guarantee it in Writing for Ten Years.*

Cover (No. 1) is cast in one piece with the guide, which permits the plunger (No. 4) to be in perfect alignment with the seat (No. 5) when closing.

Diaphragm (No. 3), the heart of the Trap, is held securely in place between the adjusting screw (No. 2) and the plunger (No. 4). It is therefore a separate and independent unit not attached to any part of the Trap Body, permitting the Diaphragm to be removed without disturbing the adjustment, as this can be done from the exterior of the Trap.



MONASH Type "C" Element

These exclusive features in the MONASH Trap are covered by United States and Foreign patents.

O-E Specialty Mfg. Co.

Manufacturers of O-E Vapor-Vacuum and Hot Water Heating Specialties
1710-1712 St. Paul Avenue, **Milwaukee, Wis.**
Representatives in All Principal Cities

No. 1

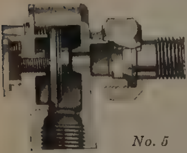
No. 2

Nos. 1 and 2—O-E Improved High-Grade Packless Supply Valves for Vapor, Vacuum, Steam or Hot Water. Can be furnished in the following patterns: Lock Shield, Globe, Straight Way, and Right and Left-Hand Corner.

No. 3

No. 4

Nos. 3 and 4—The O-E Ball Check Water Seal Condenser Return Fitting with adjustable air vent and O-E Air Exhauster and Vacuum Valve with the O-E Graduated Packless Supply Valve are designed for the simplest and most flexible heating system ever devised. Send for Bulletin "K."



No. 5

No. 5—Interior view No. 1 and No. 5 O-E Thermo-Nickel Return Trap for vapor, vacuum or pressure heating systems. Guaranteed to remain closed on a vacuum pump system. Thermal members practically indestructible.

Roughing-in Dimension and Capacities

No.	Capacity Sq. Ft. Direct Radiation	Pipe Connection In.	*A* Center Line Outlet to End of Spud In.	*B* Face of Outlet to End of Spud In.
5	75	½	2¼	1¾
1	200	½	2¼	1$\frac{13}{16}$
1	500	¾	2¾	2¼

No. 6

No. 6—O-E Float Drip and Blast Traps are highly efficient, positive in action and are entirely dependable for dripping low or high-pressure steam mains risers, vento coils, etc., without the loss of steam. Made in sizes ½ to 2 in.

No. 7

No. 7—O-E No. 2½ Direct Differential Boiler Return Trap is infallible for returning condensation to boiler on any vapor-vacuum one or two-pipe gravity steam heating systems. Capacity 4,500 sq. ft. direct Radiation. Pipe connections 2 in., steam ¾ in., air vent ½ in., No. 4 with outside mechanism 3,500 sq. ft., No. 5, 6,500 sq. ft., No. 6, 9,250 sq. ft.

No. 8

No. 8—O-E Vacu-Float Vents made in two sizes, ⅜ in., No. 15 and ¾ in., No. 30. Vents quickly and freely closes against water or steam.

No. 9

No. 9—O-E Flow Control Hot Water Fitting for controlling hot water circulation in both Heating and Plumbing installations. For either gravity or Forced circulation heating systems this Fitting substitutes for and interchanges with the Standard Union Elbow commonly used on the return connection of Hot Water radiators. The outstanding advantage of the O-E Flow Control Fitting is the ease with which the flow orifice can be adjusted without the necessity of draining the water from the system.

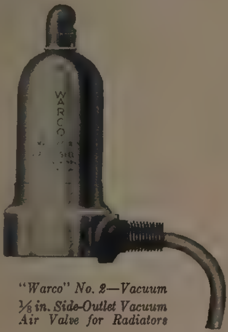
We are also manufacturers of O-E No. 1 and No. 2 Vacuum Gauges, O-E No. 2 and No. 3 Damper Regulators, O-E Frost Proof Fitting, O-E Dirt Strainers, O-E No. 7 Vacu-Quick Vents, O-E Thermo-Nickel air line valves, and O-E Automatic air valves and vents.

Data Pertaining to any of the Above Specialties Cheerfully Furnished on Request

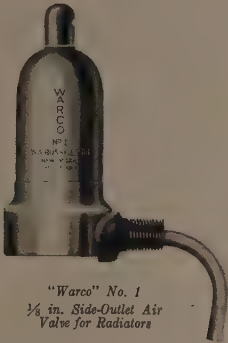
W. A. Russell & Company

Grand Central Terminal New York

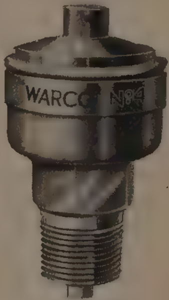
"Warco" Automatic Air & Vacuum Valves



"Warco" No. 2—Vacuum
⅛ in. Side-Outlet Vacuum Air Valve for Radiators



"Warco" No. 1
⅛ in. Side-Outlet Air Valve for Radiators

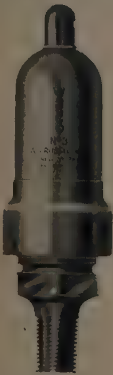


"Warco" No. 4
¾ in. Bottom-Outlet Quick Vent Air Valve for Mains and HV Stacks

In concentrating on seven perfected "WARCO" Air and Vacuum Valves, W. A. Russell & Co. offer what experience has shown to be the valves that fill every air and vacuum valve need.

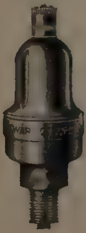
W. A. Russell & Co. have specialized in air valve manufacture for more than 39 years, and have embodied many unique and original mechanical improvements in "WARCO" Valves.

Every "WARCO" Valve is tested under actual steam conditions, and guaranteed for a period of five years when properly installed.

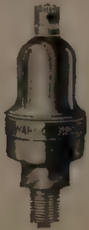


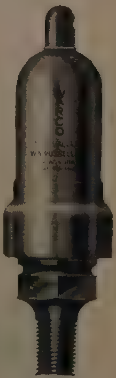
"Warco" No. 3
¼ in. Bottom-Outlet Air Valve for Mains, Coils and Risers

"Warco" No. 5
⅜ in. Bottom-Outlet Quick Vent Air Valve for Mains and HV Stacks



"Warco" No. 6—Vacuum
⅜ in. Bottom-Outlet Quick Vent Air and Vacuum Valve for Mains and HV Stacks





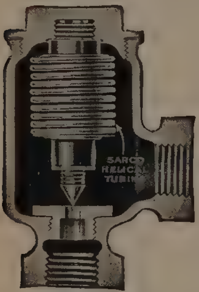
"Warco" No. 3-V Vacuum
¼ in. Bottom-Outlet Air and Vacuum Valve for Mains, Coils and Risers.

Sarco Co., Inc.

183 Madison Ave., New York

BALTIMORE BOSTON BUFFALO CHICAGO CLEVELAND DETROIT PHILADELPHIA
PITTSBURGH ST. LOUIS

RADIATOR, BLAST AND STEAM TRAPS,
PACKLESS INLET VALVES, TEMPERATURE REGULATORS AND STRAINERS



For Steam Pressure from 0 to 30 lb. Fig. 9–1 can be used. It has the same capacities as Fig. 9–2 but is furnished with brass composition valve heads and seats.

SARCO STEAM TRAP No. 9

For pressures 0 to 100 lb.

For industrial purposes, hospitals, laundry and kitchen equipment. Sarco Steam Trap No. 9 consists of a heavy bronze body with a powerful motor element of helical seamless bronze tubing containing an expansion fluid.

Is of the balanced pressure type, suitable for any steam pressure from 0 to 100 lb. *without readjustment.*

Has unusually great capacity, large valve area and quick, high lift when discharging. Cannot air bind.

Write for Booklet No. HV-230.

Size In.	Price, Each Type No. 9–2	Price, Each Type No. 9–1	Dimensions Inlet to Outlet	Capacity Lb. per Hour
½	$ 8.50	$ 7.50	1¾"	500
¾	11.50	10.50	1¾"	600
1	14.50	13.50	2"	800

SARCO HIGH AND LOW PRESSURE BLAST TRAPS

No. 9-3 and 9-4 (entirely Thermostatic)

This Heavy-Surface or Blast Trap is for draining steam coils of hot water tanks, vento stacks and main drip lines; also where a large capacity trap is required such as for draining coils in dryers, vacuum pans, heating coils, cooking vessels, etc.

Will handle great flows of condensation without loss of steam. Is entirely thermostatic, so removes the air as well as water.

Operates on the same principle as the Sarco Steam Trap No. 9–2.

No. 9–3, PRESSURES 0–30 LB.
Brass Composition Valve Head and Seat

	List Prices F. O. B. Bethlehem, Pa.	Capacities Lb. per Hour
1"	$25.00	1,000
1¼"	27.50	1,000
1½"	30.00	1,500
2"	37.50	2,000

Can be furnished in offset patterns at same prices.

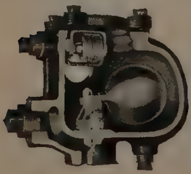
No. 9–4, PRESSURES 0–100 LB.
Monel Valve Head and Seat

	List Prices F. O. B. Bethlehem, Pa.	Capacities Lb. per Hour
1"	$30.00	1,250
1¼"	32.50	1,250
1½"	35.00	3,250

Write for Blast Trap and Heavy Service Booklet.

F. T. 1 (Float and Thermostatic)

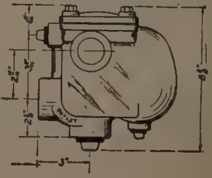
Recommended for live drips, large heating units, vento stacks, hot water tanks, etc. Two inlet and two discharge connections tapped 1¼ in. are provided and can be adjusted to the size specified. The thermostatic by-pass releases air. The under-slung valve head insures large capacity and reduces wear.



Capacity in pounds of water per hour at pressure differential per square inch.

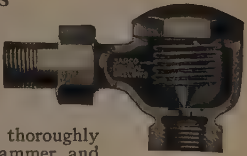
½ lb.	550	5 lb.	1600
1 lb.	725	7½ lb.	1800
2 lb.	1000	10 lb.	2000

List Price: ¾ in., 1 in., 1¼ in., $25.00
F. O. B. Bethlehem, Pa. Weight: 15 lb.



SARCO RADIATOR TRAPS

Type E



Type H

For vacuum, vapor and low-pressure heating systems. The Sarco is of the thermostatic type, using Seamless Helical Bellows and a volatile liquid filling. Its positive action keeps radiators thoroughly drained, preventing water hammer and air binding.

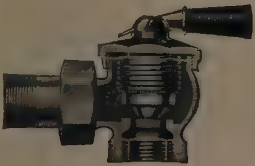
Helical Bellows is phosphor bronze. It has a high lift, insuring free discharge, a maximum closing pressure and an unusually long life. Body is heavy brass, nickel plated. Can be used on all pressures up to 25 lb. without adjusting.

Write for Booklet HV-110.

List Prices F.O.B. Bethlehem, Pa.			Dimensions		Capacity—Direct Radiation	
			Center Outlet to Inlet	Center Inlet to to Face of Outlet	Vapor System Sq. Ft.	Vacuum System Sq. Ft.
Type E	½"	$ 6.00	3¼"	1½"	200	250
Type E	¾"	8.00	3¼"	1½"	600	800
Type E	1"	15.00	3⅝"	2"	1500	1800
Type H	½"	5.00	3¼"	1½"	125	150

Angle, straightway and offset types are furnished at same prices.

SARCO PACKLESS INLET VALVE



For use on vapor and vacuum heating systems. This valve cannot leak as it is of the true Packless type.

By the use of the Sarco Helical Tubing it eliminates the necessity for packing of any kind.

Valve opens or closes with a three-quarter turn and the pressure is always even, smooth and regular. Easy to turn. Dial is distinctly marked.

Has heavy brass, well-nickeled body. Furnished with lever or round moulded handles.

Write for Booklet HV-170.

List Prices F. O. B. Bethlehem, Pa.		Center Inlet to Outlet	CAPACITIES Feet Direct Radiation
½"	$5.50	3"	up to 40 sq. ft.
¾"	6.00	3"	41 to 75 sq. ft.
1"	7.50	3½"	76 to 125 sq. ft.
1¼"	9.50	3½"	126 to 200 sq. ft.
1½"	12.00	......	201 to 300 sq. ft.

SARCO TEMPERATURE REGULATORS

Type TR-21

Sarco Temperature Regulators are self-contained and self-operating. No auxiliaries such as air, water or electricity are required. They operate thermostatically by the expansion of a heavy hydro-carbon oil and are positive in action. Will operate steam, gas or water valves and can also be supplied to open with rise in temperature.

They can be used for hot water tanks, cold storage plants, dry room or kiln control and for any specified temperature from 30 to 300 deg. fahr.

Sarco Regulators can also be furnished to meet special conditions. Inquiries are invited.

Write for Booklet HV-60.

SARCO SELF-CLEANING STRAINER

For Steam, Water and Oil Lines. Write for Booklet HV-200.

SARCO AIR ELIMINATOR

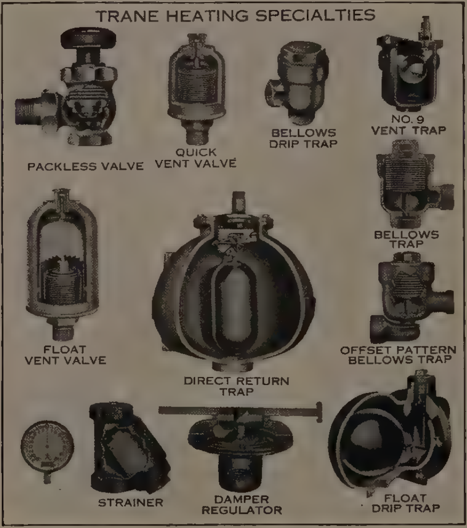
Has a capacity of 15,000 sq. ft. of Direct Radiation based on one ounce pressure. Has ¾ in. port area and is fitted with union connection.

The Trane Company

La Crosse, Wis.

See Pumps, page 766; Unit Heaters, page 679; Heat Cabinets, pages 654-655.

BRANCHES IN ALL PRINCIPAL CITIES



TRANE HEATING SPECIALTIES

Bellows-Packless Valves—Trane Valves are strictly packless. A special arrangement of ten-corrugation bellows makes the use of packing unnecessary and does away with all the inherent evils attending its use.

Brass bodies and tops. Nickel plated. Non-rising stem. Composition wheel handle. Lever handle furnished as special. Indicator standard with wheel handles. Tension spring under Bakelite collar on stem prevents valve opening or closing from vibration. Bellows guide insures proper seating and prevents bellows twisting. Only up and down movement possible.

Standard valves furnished in ½, ¾, 1, 1¼, 1½ and 2 in. sizes. Right and left-hand corner pattern valves furnished in ¾ in. size. Straightway patterns available in ¾, 1 and 1¼ in. sizes.

Chain and wheel attachments for ceiling radiation, lock and key type for public buildings, etc.

Trane Vents—For venting air from heating systems, steam coils, blast coils and Unit Heating Systems.

Float Vents—Trane Float Vents close against steam and water. Also close to retain a vacuum in a system.

Brass body. Nickeled finish. Equipped with Trane fourteen-corrugation bellows for closing against steam. Copper float closes against water. Full ¼ in. venting port. Aluminum flapper prevents air returning to the system after it is once expelled. Outside diameter $3\frac{13}{32}$ in. Bellows guaranteed for five years.

Quick Vents—Brass Body. Nickeled finish. Equipped with Trane fourteen-corrugation bellows. Closes against steam only. Also closes to retain a vacuum in the system. Full ¼ in. venting port. Aluminum flapper prevents air from returning to the system once it is expelled. Outside diameter 1 19/32 in. Bellows guaranteed for five years.

Trane Gauges—Small 4½ in. gauge has black body. Nickeled finish. Easily-read figures. Two styles—Vapor-Vacuum and Vacuum. Compound Vapor-Vacuum reads from eighteen inches vacuum to thirty pounds pressure. Bourdon spring movement.

Large 8½ in. gauge has black body and brass rim. Bourdon spring movement. For high boilers and dark boiler rooms. Reads from 30 in. vacuum to 30 lb. pressure.

Trane Strainers—Cast iron bodies. Heavy brass perforated open end screen easily removed for cleaning. Operate in either vertical or horizontal position. Furnished in five sizes, ½, ¾, 1, 1¼ and 1½ in. Screen easily removed for cleaning.

Trane Direct Return Traps—The Direct Return Trap is essentially a safety device. No matter how carelessly the system is fired this Direct Return Trap returns the water to the boiler. Guaranteed for pressures up to 20 lb. Furnished in three sizes, No. 10, No. 210, No. 310.

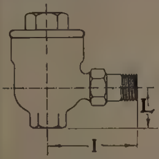
Trane Damper Regulators—Trane Damper Regulators are sensitive to the slightest change in boiler pressure. An ounce of pressure operates it and gives even temperatures at all times. Rubber diaphragm constantly in water—a preservative. Only one weight to adjust.

Trane Bellows Radiator Traps—Trane Bellows Radiator Traps are equipped with the Trane standard fourteen corrugation bellows. The bellows are made of seamless, jointless copper. Guaranteed operating range from any vacuum to 25 lb. pressure for low pressure traps and from 25 to 125 lb. pressure for high pressure traps. Bellows are guaranteed for 5 years.

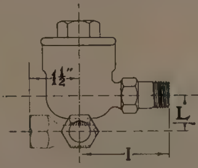
Offset Pattern Trap—This trap has the same general characteristics as standard Trane Angle Traps. Same capacities. Exactly the same in construction except for its adjustable outlet fitting, which may be adjusted to any angle desired thus facilitating pipe fitting and simplifying stocking.

Trane Thermostatic Drip Traps—Trane Bellows Drip Traps are available in low or high pressure styles. Ideal for dripping ends of mains or on steam condensing equipment where drop in temperature of condensate is necessary to prevent re-evaporation. Fourteen-corrugation bellows. Operating range from any vacuum to 25 lb. pressure.

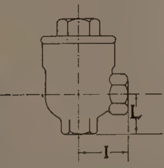
Trane Float Drip Trap—A heavy duty product for handling large volumes of condensate. Cast iron body. Seamless copper float. Double-acting brass mechanism. Horizontal seating type discharge valve. Cleanout plug in bottom. Standard fourteen-corrugation bellows controls air elimination orifice. Two inlet and two outlet openings on No. 1 and No. 3 Traps. Either may be used. Trap cannot become air bound as air is eliminated through a thermostatically controlled port.



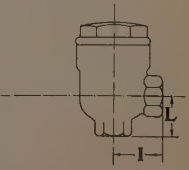
Angle



Offset



High Pressure



Drip

SIZES, CAPACITIES, ETC., OF TRANE RADIATOR TRAPS

Size	Capacity in Sq. Ft. at Various Pressure Differences					
	4 oz.	8 oz.	1 lb.	2 lb.	5 lb.	25 lb.
½"	200	375	395	560	880	1960
¾"	400	585	770	1080	1720	3850
1"	800	1125	1600	2250	3560	7950

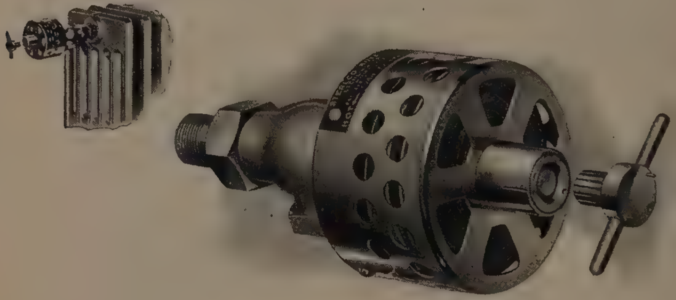
	DIMENSIONS, INCHES		
	Size	L	I
Angle.........	½ and ¾	1 7/16	3¼
Angle.........	1	1¾	3⅜
Offset.........	½ and ¾	1 7/16	3¼
High Pressure and Drip	½ and ¾	1 7/16	1 11/16
High Pressure and Drip	1	1¾	2

Sizes conform to recommendations of *Heating and Piping Contractors' National Association.*

Sterling Engineering Co.

1626-44 Holton Street **Milwaukee, Wis.**

Sales Agencies in All Principal Cities

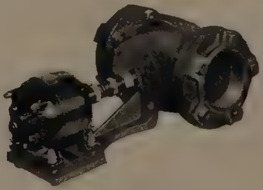


THE THERMOTROL

A self-contained, automatic temperature control valve. Adaptable for vapor, vacuum, or low pressure two pipe steam heating systems.

¾ in. Capacity 70 sq. ft. of Direct radiation
1 in. Capacity 150 sq. ft. of Direct radiation
1¼ in. Capacity 250 sq. ft. of Direct radiation
1½ in. Capacity 300 sq. ft. of Direct radiation

NOTE—Also adaptable for hot water heating systems.



THE COMPELLER

For stimulating the circulation in hot water heating systems or domestic hot water or ice water circulating systems.

No. 2½—Furnished with companion flanges tapped 2½ in. or under.
No. 4 —Furnished with companion flanges tapped from 3 to 4 in.
No. 6 —Furnished with companion flanges tapped from 4½ to 6 in.

Vapor Engineering Company

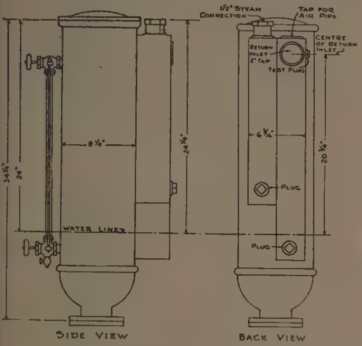
489 Fifth Avenue
New York City
Chas. E. Scott—R. C. Willis

10 South 18th Street
Philadelphia, Pa.
J. W. Glassey—M. S. Buck

VECO VAPOR SPECIALTIES

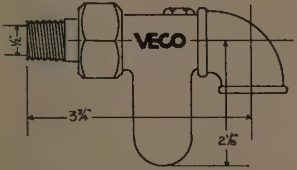
Non Mechanical and Positive in Operation

Engineers for the design of "open-to-atmosphere" vapor heating systems for factory, public and residential buildings, regardless of size, construction or location. Veco Vapor specialties are the result of 21 years of specialization in vapor heating work



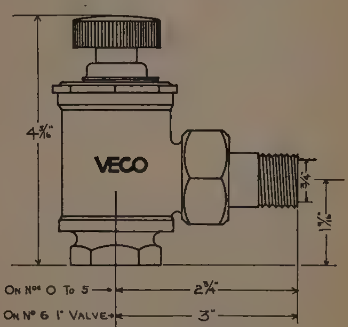
VECO GOVERNOR

Combining, Safety Valve, Air Eliminator and positive control of Boiler draft, Gas supply valve, or Oil Burner



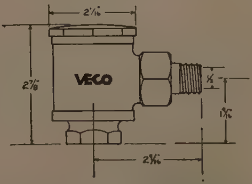
VECO RETURN SEAL

No moving parts. For all standard vapor work



VECO SUPPLY VALVE

Packless, Leakless, Graduated.
¾ in. Nos. 0 to 5 up to 139 sq. ft. inclusive.
1 in. No. 6 up to 140 to 150 sq. ft. inclusive.



VECO THERMOSTATIC TRAP

For Central Plant work, Ventilating Units, etc.

Full cooperation is offered to Architects, Engineers and Contractors in the planning of Veco Systems which are fully Guaranteed as to material—and satisfactory operation.

ESTABLISHED 1888

WARREN WEBSTER & COMPANY

Pioneers of the Vacuum System of Steam Heating

Camden, N. J. **Branches in over 50 Cities**

since 1888 Webster Systems of Steam Heating

Manufacturers of Webster Systems of Steam Heating and Webster System Equipment—Webster Series "78" Traps for "Process" Steam Pressures—Steam and Oil Separators and Expansion Joints

"78"
-for users of process steam

Webster Products

Webster Moderator System of Steam Heating.

Webster Vacuum and Type "R" Systems of Steam Heating.

Webster System Apparatus: Including Sylphon Traps; Diaphragm (No. 7) Traps; Modulation Supply Valves; Sylphon Quick-Opening Packless Valves; Dirt Strainers; Dirt Pockets; Drip Traps; Heavy-Duty Traps; Double Service Valves; Water Accumulators; Expansion Joints; Lift Fittings; Suction Strainers; Vacuum Governors; Hy-lo Traps and Controllers; Damper Regulators; Vent Traps and Vent Valves; Boiler Return Traps; Air Separating Tanks. Steam and Oil Separators.

Webster Series "78" Traps for "Process" steam pressures (10 to 100 lb. per sq. in.).

Webster Service

—delivered through more than 50 Branch Offices, places at the disposal of engineers, architects, and heating contractors accurate, comprehensive information resulting from the extensive experience of this organization.

Webster MODERATOR System

A fundamentally new development in steam heating which varies the quantity of steam admitted to the building as a whole and to each radiator in particular—balancing the supply of heat with changes in outside temperature and normal inside demand.

This system gives fully automatic variation of steam supply to provide for changes in demand resulting from (1) variation in outdoor temperature (2) from shutting off or turning on of radiation; to compensate for (3) variation of steam pressure above the minimum resulting from uneven firing and (4) in vacuum systems, for variation in degree of vacuum in returns within limits established for the system.

It also gives convenient manual control of steam supply to provide for changes in demand resulting from changes in weather conditions other than temperature and to provide for quick heating up and night load conditions.

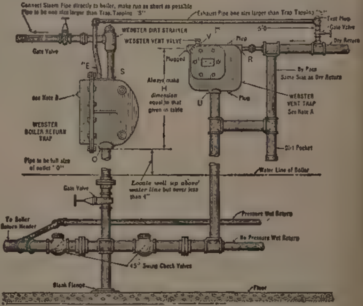
Each Webster MODERATOR System must be *made to order* for the requirements of the individual building, with the result that production is limited at present. Future installation of this system in new buildings can be arranged for by installing a standard Webster Vacuum or Type "R" System with provision for later addition of MODERATOR System equipment and advantages.

Webster Vacuum Systems

—are particularly suited to large buildings, or where "process" steam is used and the exhaust utilized for either direct radiation, or in combination with blast coils or unit heaters . . . operating on either low-pressure live steam or exhaust steam, or a combination of both.

Webster Type "R" System

A two-pipe, open return line, low pressure steam heating system adaptable to almost every type of building, except the very largest, where Webster Vacuum Systems are used. For installations from 500 to 32,000 sq. ft. of direct radiation. The only limitation is the necessity for a basement or other depression so that the boiler may be placed with its water line below the level of water of condensation flowing back to it. The combination of the Webster Boiler Return Trap and Webster Vent Trap incorporated in this system provides maximum safety with open return line simplicity.



Conventional Arrangement of Piping Around Webster Boiler Return Trap, Sizes 023 to 323, in the Webster Type "R" System of Steam Heating

TABLE I. Webster Type "R" System Basement Equipment

Size of Boiler Return Trap	Rating, Sq. Ft. Direct Radiation	Number of ½-in. Vent Valves	Size of Vent Trap
0023	1500	1	0023
023	2500	1	023
123	4000	1	123
223	8000	2	223
323	16,000	3	323

For installations over 16,000 sq. ft., two Boiler Return Traps and a Duplex Vent Trap are used. See Webster Service Details.

In the following columns are listed Webster Systems Equipment. Roughing-in dimensions are given in inches. Consult Webster Service Details for complete installation instructions.

Webster Sylphon Packless Q.O. Valves

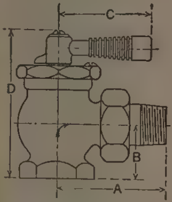


TABLE II
Dimensions

Size	A	B	D
½	2 5/8	1 1/4	3 5/8
¾	2 3/4	1 3/8	3 7/8
1	3 1/8	1 3/4	4 3/4
1¼	3 5/8	1 7/8	4 7/8
1½	3 7/8	2 3/16	5 3/8
2	4 3/8	2 7/16	5 5/8

Webster Type "W" Modulation Valves

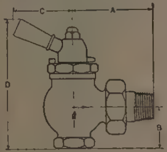


TABLE III
Dimensions

Size	A	B	D
½	2 3/4	1 1/4	4 1/8
¾	2 3/4	1 1/2	4 5/8
1	3 1/8	1 3/4	5 1/2
1¼	3 1/2	2	6

Webster No. 7 Traps

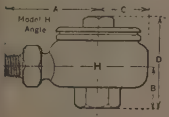


TABLE IV—Dimensions

Size	A	B	D
½-712	3 1/4	1 7/16	3
½-722	3 1/2	1 7/16	3 3/16
¾-713	3 3/4	1 7/16	3 1/8
¾-723	3 3/4	1 9/16	3 1/4
¾-733	4 1/2	1 7/8	4 9/16
1 -744	4 3/4	2	4 9/16
1¼-745	4 3/4	2	4 9/16

Webster Sylphon Traps

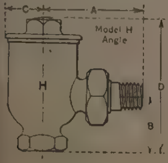


TABLE V—Dimensions

Size	A	B	D
½-512	3 1/8	1 5/8	4
¾-513	3 1/8	1 3/4	4 1/8
½-522	3 1/4	1 7/8	5 1/4
¾-523	3 1/4	2	5 3/8
¾-533	4	2 3/8	5 3/8
1 -534	4	2 5/8	5 5/8
1 -544	4 1/4	2 9/16	6 7/8
1½-545	4 1/2	2 9/16	6 7/8

Webster Dirt Strainers—Series 18

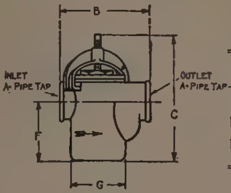


TABLE VI
Dimensions

Size	B	C	F
½ or ¾	4 1/4	6	2 3/4
1 or 1¼	5 1/2	7 5/16	3 1/2
1½ or 2	7 1/4	9 8/16	4 3/4

Webster Heavy Duty Trap—Series 19T

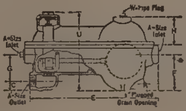


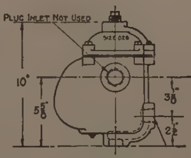
TABLE VII
Dimensions

Size	A	C	E
0019T	¾	1	12 5/8
019T	1	1	15
119T	1¼	1 1/2	18 3/8
219T	2	1 5/8	19 7/8

Webster Drip Trap—Series 026

A heavy duty trap, handling large volumes of condensation and air. Compact and light in weight. Suited for drips of mains, unit heaters and similar applications. Specifications calling for a heavy-duty float-type trap is fully met, while the advantages of the thermostatic element and ease of installation are both retained.

Webster Drip Trap



Dimensions

Outlet openings on both end and the bottom permit discharge of water, or water and air, either vertically or horizontally. An opening in the cover of the trap is provided so that air may be discharged separately when desired. In the bottom of the trap is a plugged opening which serves as a cleanout.

Ratings range from 500 lb. per hour at ¼ lb. pressure difference to 1800 lb. at 10 lb. pressure difference.

Webster Series "78" Thermostatic Traps

Webster Series "78" Thermostatic Trap

Webster Series "78" Thermostatic Traps have been developed to meet the needs of users of "process" steam at 10 to 100 lb. per square inch. When installed in accordance with the recommendations of Webster Service, they provide the answer to a multitude of problems of efficient discharge of air and water of condensation from process-steam using equipment. Increased production through quicker heating-up and higher maintained temperature of heating surfaces result.

Design and Construction: Unusual construction features include automobile-type copper-asbestos gasket, heavy-gauge monel metal diaphragm, renewable stainless steel valve piece and seat, expanded opening for quiet operation, cast steam brass body, and hot forged brass cap bolted on with monel metal tap bolts.

Sizes and Types: Webster Series "78" Thermostatic Traps are made in ⅜, ½, ¾ and 1 in. sizes and in two pressure classes. Class 2 Traps are designed for pressures from 10 to 50 lb.; Class 3 Traps for 50 to 100 lb. pressures.

Ratings: The range of application of Webster Series "78" Traps is limited only by the following three factors: (1) Pressure of 10 lb. (or less) to 100 lb. per sq. in. (2) Volume of condensation ranging from 60 to 1210 lb. of water. (3) Not to be used with superheated temperature.

TABLE VIII

Ratings of Webster "78" Thermostatic Traps

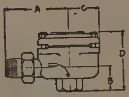
Size of Trap	Size of Tappings		Class 2 Working Pressures up to 50 lb. per sq. in.				Class 3 Working Pressures, 50 to 100 lb.					
			Pressure Differential, Pounds per Square Inch				Pressure Differential Pounds per Square Inch					
	Inlet	Outlet	10	20	35	50	20	35	50	65	80	100
			Pounds of Water per Hr.				Pounds of Water per Hour					
780	⅜"	⅜"	20	40	80	120	30	50	68	85	100	115
782	½"	½"	60	95	140	185	75	110	145	180	210	245
783	¾"	3"	130	225	330	435	165	245	325	405	470	545
784	1"	1"	300	465	685	900	375	550	725	900	1040	1210

Note.—The pressure differentials given in this table refer to pressures existing at the inlet of the trap and in the return line.

Application: Webster Series "78" Thermostatic Traps may be used to advantage in hundreds of different applications. Most of these fall into three groups.

1. To discharge both air and water of condensation from single pieces of apparatus within its capacity.
2. For installation on each unit of a battery—as for example a battery of kettles instead of the old fashioned method of trying to handle the entire battery through one "master" trap.
3. For venting air *only* from apparatus formerly provided with handcock or other similar inadequate means, and where volume of condensation is handled by a "bucket type" trap.

TABLE IX
Dimensions



No. of Trap	A	B	C	D
780	2⅝	1 13/16	1¼	2¾
782*	3½	1 7/16	1⅝	3¼
783	3¾	1 7/16	1⅞	3⅞
784	4⅜	2	2⅜	4⅜

Class 2 Trap—10 to 50 lb. pressure.

Class 3 Trap—50 to 100 lb. pressure.

*782 Trap furnished on special order with ⅜-in. nipple to fit the standard ½-in. union nut. Other dimensions unchanged.

Webster Series "78" Dirt Strainer

The Webster Series "78" Dirt Strainer has been provided to be placed ahead of every Webster Series "78" Thermostatic Trap located at a drip point in the supply piping or attached to apparatus which is likely to contain core, sand, pipe scale or sediment.

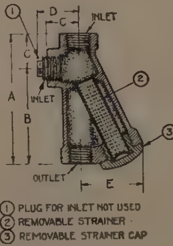


TABLE X
Dimensions

Size, in.	A	B	C
782-½	4½	3⅜	1⅛
782B-½	4½	3⅜	1⅛
783-¾	4 13/16	3½	1 5/16
784-1	5 9/16	4⅛	1 7/16

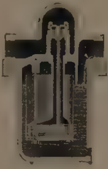
Wright-Austin Co.

315 W. Woodbridge Street
Detroit, Mich.
Representatives in Principal Centers

Exhaust Heads
Water Columns
Pump Governors

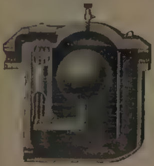
Made to order
Separators
Air Traps

"Airxpel" Bucket Type Steam Trap
0 to 300 lb.



Expels entrained air automatically. Unusually large capacity. Has exceptionally long life without repairs, because of simple, one lever construction. All parts are accessible at all times. Straight line horizontal pipe connection, making it easy to install; low weight, hangs on the pipe line. Monel metal valves and seats in a valve holder which regrinds the valve as the Trap operates, keeping it steam tight.

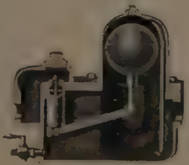
"Emergency" High Pressure Steam Trap
0 to 250 lb.



Three valve Trap with exceptionally large capacity at high loads and no wire drawing at low loads. No change of valves or adjustment of any kind from 0 to 200 lb. Capacity increases with pressure. All internal mechanism attached to and removable with the cover. Straight line horizontal connections. Strong nickel float. An exceptionally reliable Trap for shipment to foreign lands or out of the way places.

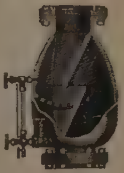
"Victor" Low Pressure Steam Trap
0 to 20 lb.

Especially designed for low pressure. The valve opens outward with the flow of condensate, giving enormous capacity. Will discharge without pressure, which is valuable in starting up a cold system. An excellent oil and grease Trap. Very simple in construction, having only three moving parts. Used extensively on central station heating systems, on vento coils and on vacuum returns, in which case, the Trap is provided with a thermostatic air valve.



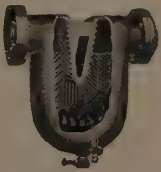
The two Separators illustrated here are part of one of the most complete lines of types and sizes in the world. These include cast semi-steel Separators, cast steel, riveted steel and welded steel Separators made in all sizes for all classes of service for both steam and oil.

Type "A" Vertical Steam Separator
0 to 250 lb.



For average service. Will eliminate dirt and moisture from steam down to ½ of 1 per cent; cast in one piece and self cleaning, requiring no maintenance after installation. The Type "A" has been standard for 35 years and there are many thousands in successful use. Installed just ahead of the throttle of an engine; it improves efficiency, checks vibration and prevents accidents.

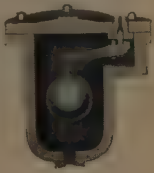
Type "B" Horizontal Steam Separator
0 to 250 lb.



Can be placed close to walls or ceiling, because body of Separator hangs below pipe line. Self-cleaning, cast in one piece, no maintenance required. Will remove moisture down to ½ of 1 per cent.

Air Trap for Relieving Air from Hot and Cold Water Systems

Extreme simplicity and reliability characterizes this Air Trap. There is nothing to it but a float, a lever and a valve. Nothing to get out of order, no overflow needed, ample valve opening, 7 in. high by 6 in. diameter, reasonable in price.



Webster Tallmadge & Co., Inc.

50 Church Street, **New York, N. Y.**

HIGH EFFICIENCY HEATING SYSTEMS

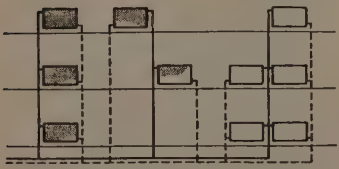
Tallmadge Methods insure better economy, comfort, health and proficiency from correct heating of buildings, and in process work in industrial plants.

The first cost of Tallmadge Heating Systems is lower and the complete story is told in the Bulletin "Correct Heating," which also covers Electrical Control of Zoned Orifice Distribution.

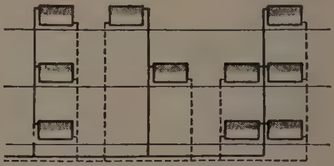
Some of the outstanding advantages of the orifice type of steam distribution are:

1. Low steam consumption of radiators, in mild weather with just enough heat to supply the building losses, maintaining a more healthful atmosphere and greater operating economy.
2. Simplicity of control, minimum of devices and less elaborate piping makes these systems economical to operate and lowers maintenance expense.
3. Permits zoning of buildings for various heating and weather requirements with resultant fuel saving.

Type E Tallmadge Valve Control Mechanism



With reduced steam supply and ordinary distribution the closest radiators get all the steam



With Tallmadge Orifice System the supply to each radiator is correctly proportioned

In the design and operation of the orifice type system, reference to the accompanying diagrams, indicates recognition of the following facts:

1. The most valuable heat obtainable from the steam in a radiator is the latent heat. A heating system should therefore operate at approximately 100 per cent thermal efficiency, as compared with modern power plants which have only 20 per cent economy because of loss of this latent heat.
2. If the steam supply to a radiator is reduced it will be observed that the upper portions of the radiator will be hot and the lower portions cold. It is therefore often unprofitable to pump the return water long distances back to the boilers as there is no appreciable heat left.
3. When the steam flows into the top of a radiator, the air being heavier, if permitted to freely do so, will naturally flow out of the bottom and no unusual device is required to make it do so.
4. With the orifice system of distribution, the supply of steam to the radiators is so easily controlled that return valves, or radiator traps, are not essential.
5. If the return pipes are either vertical or have a slight uniform pitch downward with the flow, it is not necessary to go to the expense of pumping a vacuum on the return piping. An ordinary return water receiver with open vent pipe to let the air out and a pump to put the water back into the boilers are all that are necessary.
6. The modern method of selecting steam supply pipe sizes is to keep the frictional resistance or pressure drop in the steam mains within certain percentage limits of flow to the more remote radiation.

TALLMADGE SERVICE

Corrects operation in any type or size of plant. **Power—Process—Heating.**
Practical Surveys and Reports by trained technical men.

Johnson Service Company

General Offices and Factory

Milwaukee, Wisconsin

Albany, N. Y.
Atlanta, Ga.
Baltimore, Md.
Boston, Mass.
Buffalo, N. Y.
Chicago, Ill.
Cincinnati, O.
Cleveland, O.
Dallas, Texas

Denver, Colo.
Des Moines, Ia.
Detroit, Mich.
Greensboro, N. C.
Indianapolis, Ind.
Kansas City, Mo.
Los Angeles, Calif.
Milwaukee, Wis.

Minneapolis, Minn.
New York City, N. Y.
Philadelphia, Pa.
Pittsburgh, Pa.
Portland, Oregon
Salt Lake City, Utah
San Francisco, Calif.
St. Louis, Mo.
Seattle, Wash.

JOHNSON TEMPERATURE REGULATING CO. OF CAN., LTD.,
44 Adelaide St., E. Toronto, Ont., Can.

Montreal, Que. Winnipeg, Man. Calgary, Alb. Vancouver, B. C.

Products and Services

ENGINEERS and CONTRACTORS for the CONTROL of TEMPERATURE or HUMIDITY for any purpose and over every range used in manufacturing purposes or buildings, furnishing and installing:

Temperature Controlling Apparatus for any and all kinds of heating and ventilating systems.

Temperature Controlling Apparatus for any industrial process requiring the medium of heat.

Control of humidity in industrial processes requiring artificial humidification.

Dual or two-temperature systems of temperature control for entire buildings.

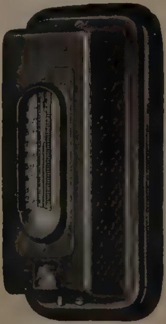
Manufacturers of thermostats and other apparatus for the control of temperature and humidity.

Johnson All-Metal Thermostats

Every Johnson Thermostat is ALL-METAL throughout, having no soft or hard rubber parts to deteriorate and become inoperative. Every thermostat exquisitely made and thoroughly tested for accuracy, efficiency and durability.

Model "P"
Lever Shutoff
Lever Adjustment

Dual Thermostat with
Push Button



Model "P"
Dial Adjustment

Johnson Intermediate or Graduated Action Thermostat

This thermostat gives a true graduated motion to mixing dampers and valves. It holds them in an intermediate position to maintain the temperature of the room accurately within one degree above or below the setting of the thermostat. This thermostat is best suited for all systems of heating and ventilating except the single pipe gravity steam system. The Johnson positive movement is manufactured for use in connection with single pipe gravity systems.

Johnson Dual or Two-Temperature Thermostat

The Dual, or two-temperature thermostat provides for a daylight temperature (usually 70 deg.) and a night-time temperature (35 to 50 deg.) as desired, for all or some of the rooms in a building, simply by the manipulation of a single push button by the engineer or other person in authority. It is an all-metal thermostat and operates valves and dampers with a gradual motion, holding them in an intermediate position to maintain the temperature of the room accurately within one degree above or below the setting of the thermostat. It is a factor for the greatest economy in school buildings, a number of rooms of which are occupied at night as well as day, and for buildings in which some of the rooms are occupied only at certain times, such as churches, auditoriums, masonic temples and lodges.

Johnson Insertion Thermostat

Designed to control temperatures within closed air chambers or ducts and tanks. The body of thermostat is a dust-proof case containing the two working parts and extending outside the chamber.

Designed, in the case of hot water tanks, for insertion through 1 in. tapped hole and controlling a diaphragm valve on the supply pipe to the steam coils in the tank. It can be used to control the temperature of any liquid, either hot or cold. It is especially adaptable for controlling the temperature of water in hot water heating plants by its control of the boiler draft doors.

Adaptable for use in bake ovens for enamels, japans, etc.; drying rooms for paints, varnishes, patent leather, etc.; storage rooms for tobacco, rubber or similar goods; sterilizers or pasteurizers, cold-storage rooms, fur vaults, etc.; refrigerator machine control; humidity control for air washers; flue gas tempered control; hot blast heating plants; combination tempered ventilation and hot blast systems; greenhouses, Turkish bath rooms, etc.; tempered ventilation for buildings.

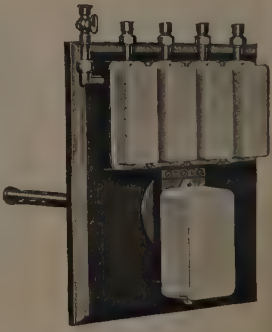
Multiple Insertion Thermostat

Similar to the insertion duct thermostat, excepting that one multiple thermostat takes the place of a number of separate duct thermostats set for different temperatures. The 4-point multiple thermostat shown will operate four separate diaphragm valves at as many different temperatures. It has become very popular with heating engineers for the control of heating and tempering coils where it is desired to have these coils turn on at different temperatures.

UNIT CALIBRATED THERMOSTAT
JSC
JOHNSON SERVICE COMPANY MILWAUKEE WIS.

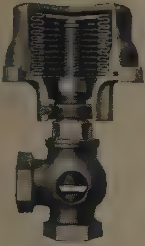
Unit Calibrated Thermostat

Liquid Insertion Thermostat

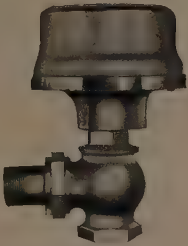


Four-Point Multiple Thermostat

Johnson Metal Diaphragm Valve



Sylphon Valve
Sectional View



Sylphon Valve
Angle

Sylphon Valve
Offset Corner

Sylphon Globe Valve

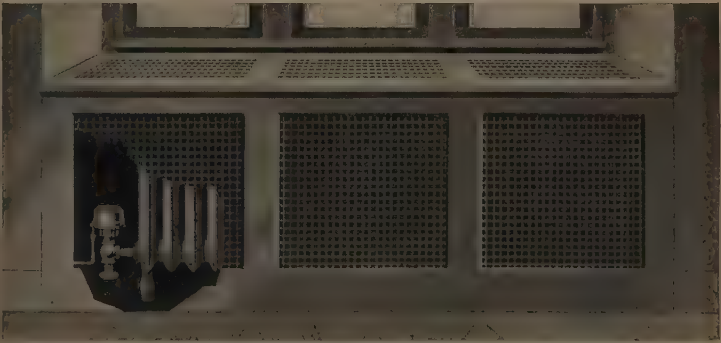
Sylphon Valve
Brass Three-Way

Flanged Globe
Coil Valve

Screwed Globe
Coil Valve

Window Seat With Radiator Behind Grill

Diaphragm valves on radiators in window seats, or behind grills, or similar enclosed spaces, operate under very severe conditions. The Sylphon valve overcomes all of the objections to placing diaphragm valves on radiators in such spaces, as the Sylphon is permanent and neither heat nor moisture can destroy its efficiency.



This valve having an indestructible 1-piece metal bellow, is permanent and requires no repairs. Its value for the control of steam is obvious and particularly so in connection with steam coils, radiators in wall boxes where excessive heat would destroy rubber diaphragms.

Pneumatic Switch Control

Remote valve and damper control plays, by means of our pneumatic switches, a very important part in the economical operation of the modern heating plant, especially in schools. It saves the janitor's time for other duties, and makes it possible to accomplish results in the operation of the heating plant which can not be obtained in any other way. It makes it easy to operate the fresh air, return air and vent dampers, with the corresponding assurance that these dampers will be economically operated as intended by the heating engineer. It also makes possible and facilitates the control of risers in office buildings in accordance with the latest practices for the economical use of steam.

Different types of pneumatic switches:

Lever handle switches.
Push button switch.
Indicating switch to open and close dampers partially as desired.
Electro pneumatic switch to open and close dampers automatically—with the starting and stopping of fan motors.

Specifications

The Johnson System of Temperature Regulation to be erected and assembled by trained mechanics employed by the manufacturer, the Johnson Service Co.

The Johnson Service Company maintains an engineering organization in each of its branch offices competent to render complete information regarding application of the equipment, location of thermostats, capacity of air compressors, humidifiers, etc., and layouts of air piping. Our engineering department should be consulted regarding specifications.

Humidity Control

The supplying of moisture to the heated air in buildings and the automatic control of the percentage of moisture in this air are recognized by authorities to be as important as maintaining proper temperatures.

Humidostats and Humidifiers

The humidostat automatically controls the supply of moisture delivered to the air by a humidifier and maintains a constant percentage of relative humidity. It operates a diaphragm valve on the steam coils in the pan humidifier. The pan is provided with float box to maintain constant water level and is located in the ventilating air duct leading throughout the building. Steam jet and water spray types of humidifiers are also furnished.

Distributing Damper Control for Ventilating Air Switchboard

National Regulator Co.

Factory and General Offices: 2311 Knox Avenue, **Chicago, Ill.**

MANUFACTURERS OF: National System of Heat Regulation; "Metaphram" Diaphragms; "Metaphram" Damper Regulators for low-pressure and hot water boilers; National Humidity Controllers; National Dampers; A-Jacks High-Pressure Steam Damper Regulators; National Cam Valves.

National Heat Regulation—National Systems of heat regulation obtain the best possible results in a simple, direct manner, avoiding complicated piping and intricate valve arrangements.

In the National System the control of valves and dampers centers in the adjustable, dust-proof National Thermostat mounted on the wall of the room to be controlled. Thermostatic action of the sensitive, imperishable hard rubber element opens and closes the leak port of the pneumatic system connected to National Metaphram Valves on radiators or National Metaphram Motors on dampers.

The National System provides for gradual control in its most successful form, together with any combination of remote control suitable for the building under consideration. Engineering assistance in plan and layout will be rendered on request, without obligation.

National "Metaphrams"—These are self-collapsing metal diaphragm units designed and patented by this Company for the specific purpose of operating valves and dampers. The sections are constructed of high-grade spring brass, which is not spun or heated in the manufacturing process, and so retains all its resiliency and strength. These diaphragms are assembled by means of finely threaded integral studs. Compressed air is applied inside the "Metaphram" and affects so large a surface that maximum power is attained with a minimum of travel.

"Metaphrams" are regularly made in sizes from 2 in. to 10 in. Correspondence is invited from engineers regarding special Metaphram assemblies.

National Dampers—(Round, Double or Louvre Types). National Dampers are operated by Metaphram Motors, and are successful under the most difficult conditions. They are made in our own shops and Metaphram motors are fitted and tested to each damper before shipment.

National Dampers may be controlled by thermostats, remote control switches or by electric-pneumatic valves operated by starting or stopping of ventilating fan motors.

Metaphram Damper Regulators—

Metaphram Damper Regulators are made in five sizes to operate dampers on any low-pressure heating boiler operating on steam, vapor or vacuum. They are extremely powerful, sensitive and durable, operating on pressure changes as low as 1 oz.; for working pressures to 15 lb. The diaphragm unit is built up of individual, self-collapsing National Metaphrams which provide a maximum of power in a minimum of travel. Every regulator is shipped complete with chain, weights, etc., and installation instructions.

Reg. No.	Boiler Con.	Ship. Wt.	List Price
AA	¾″	10#	$12.00
A-2	¾″	15#	15.00
B-2	¾″	20#	18.00
C-2	1″	35#	20.00
D-2	1″	55#	27.00
F	2″	10#	18.00

Type "F" Damper Regulator—A simple, compact thermostatic unit for controlling draft and check dampers, operating with gradual action on changes as low as 5 deg. in water temperature, insuring a controlled rate of combustion to provide uniform water temperature.

Metaphram Furnace Regulator—The principles of Metaphram Damper Regulators have been adapted to a simple warm air furnace regulator, easily installed in any return air furnace, offering automatic temperature control without resource to electric or spring-wound motors, intricate valves or room thermostat connections.

Complete details will be mailed on request.

THE POWERS REGULATOR CO.

Over 36 years of specialization in temperature control

General Offices and Factory—2719 GREENVIEW AVENUE, CHICAGO, ILL.
General Eastern Offices—137 EAST 46th STREET, NEW YORK CITY
THE CANADIAN POWERS REGULATOR CO., LTD., TORONTO, ONT.

List of Branch Offices of The Powers Regulator Co.

ATLANTA, GA.
BALTIMORE, MD.
BIRMINGHAM, ALA.
BOSTON, MASS.
BUFFALO, N. Y.
BUTTE, MONT.
CHATTANOOGA, TENN.
CINCINNATI, OHIO
CLEVELAND, OHIO
DENVER, COLO.
DETROIT, MICH.
EL PASO, TEXAS
HOUSTON, TEXAS
INDIANAPOLIS, IND.
KANSAS CITY, MO.
LOS ANGELES, CALIF.
LOUISVILLE, KY.
MILWAUKEE, WIS.
MINNEAPOLIS, MINN.
NASHVILLE, TENN.
NEW ORLEANS, LA.
PHILADELPHIA, PA.
PITTSBURGH, PA.
ROCHESTER, N. Y.
SALT LAKE CITY, UTAH
SAN FRANCISCO, CALIF.
SEATTLE, WASH.
ST. LOUIS, MO.

CALGARY
HALIFAX
MONTREAL
VANCOUVER
WINNIPEG

Products

Automatic Temperature Controlling Systems, applying them, under the supervision of Powers engineers, to the heating plants, new or old, in residences, offices, factories, schools, institutions, and to any other conditions of artificial heating where uniform temperature is desired.

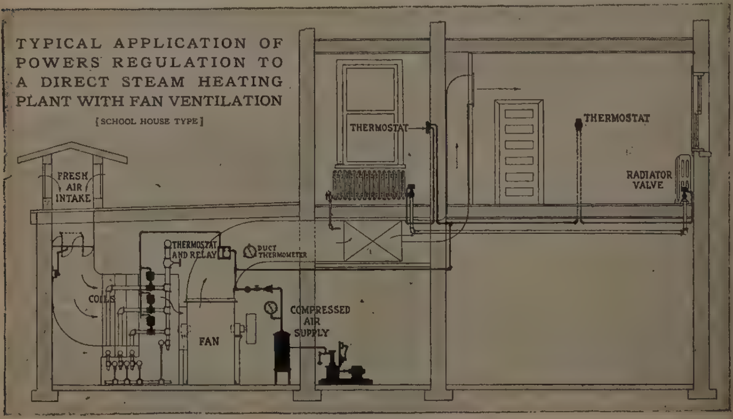
Automatic Regulators for ACCURATELY controlling temperature of Liquids, Gases and Air, Pressure Reducing Valves, High Pressure Steam Traps, Humidity Control Devices, Shower Mixing Valves, Etc.

Temperature Controlling Appliances

Powers thermostats are accurate in their working and will maintain their adjustment. They are of the vapor disc type, exclusive with Powers regulators, and are not thrown out of adjustment by extremes of temperature or long disuse. For over 35 years the accurate control obtained by this method has been the standard of thermostatic control by which all other methods are measured. In design, Powers thermostats are second to none in beauty and perfection of finish; in size, as small as is consistent with the reliability so necessary in such instruments; in operation, sure, with gradual or positive action, as conditions require.

Diaphragm radiator valves, diaphragm motors, mixing dampers and other equipment are especially rugged in construction, dependable and durable; built regardless of expense, for efficiency and long service.

Motive power used in these systems is compressed air. The company builds its


TYPICAL APPLICATION OF POWERS REGULATION TO A DIRECT STEAM HEATING PLANT WITH FAN VENTILATION
[SCHOOL HOUSE TYPE]

own air compressors, operated by steam, or electricity, and characterized by their reliability, noiseless operation, perfect control and long life.

Powers Type D Thermostat

The Powers All-Metal Radiator Valve

Installations

Installations of Powers systems are invariably made by the company. At each branch office is maintained a competent engineering and erecting force, sparing no expense to maintain the highest efficiency. Powers special devices, however, are easily installed by any engineer or contractor.

Prices

Price for Powers regulation covers the system installed complete, and is only named after a careful study of the requirements. Our price is not lowest, but no other system will be found so efficient and economical. Customers are served with the sole aim of getting results for them; and experience shows that **satisfactory service from a temperature controlling system is of much more importance than its first cost.**

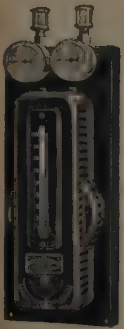
Specifications

Heating systems, and the requirements for temperature control, vary widely in detail. Much of the dissatisfaction experienced with some systems of temperature regulation is due to the attempt to force a ready-made inflexible system or device to meet special requirements, taking no account of the conditions peculiar to the situation to be treated.

For these reasons we believe special study should be given each case. We shall be glad to submit to any Architect or Engineer a detailed Specification, accompanied by a guaranteed price, to cover complete system of temperature control installed, the price to hold if specification is used. This guarantees full protection to the client against advantage being taken of a close specification. This company will gladly collaborate with Architect or Engineer in preliminary plans. As specialists in temperature control, The Powers Regulator Company has unusual facilities for solving problems in this particular field.

Catalogs

Engineers, Architects, and others who wish further information regarding the Powers System, will find it in the following books: *Elimination of Heat Waste* shows applications in schools, churches, and other public buildings, residences, etc.; *Shop and Office Temperatures* shows applications in shops, offices and workrooms, also presents proof of fuel savings and increased production due to its use.



Powers Type K Heavy Duty Thermostat

Write for Bulletin No. 251

Powers Type K Duct Thermostat

Powers Hygrostat for Humidity Control

POWERS ALL-METAL DIAPHRAGM VALVES

Low Pressure All-Metal Valve

High Pressure All-Metal Valve

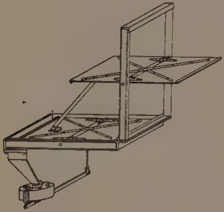
L. P. Iron Body Valve Flanged

Brine Control All-Metal Valve

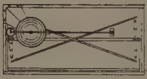
Three-Way All-Metal Valve

Write for Bulletin No. 244

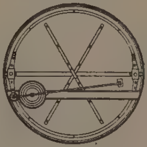
POWERS DAMPERS



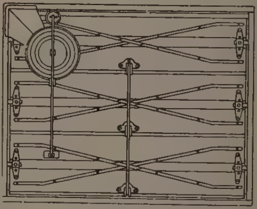
Mixing



Single



Round

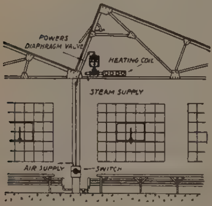


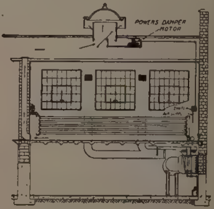
Louver

Write for Bulletin No. 244

POWERS PNEUMATIC SWITCH FOR REMOTE CONTROL

of Diaphragm Valves and Dampers

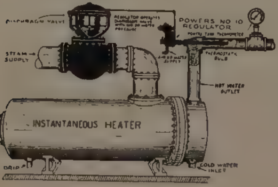


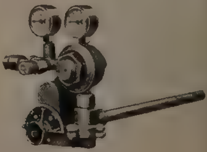


Write for Bulletin No. 257

NO. 10 REGULATOR

**operated
by Compressed
Air or
Water Pressure**

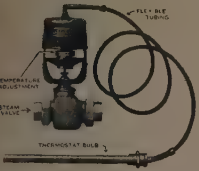




Write for Bulletin No. 216

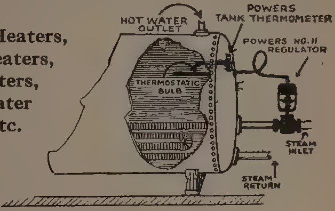
POWERS SELF OPERATING REGULATORS

POWERS NO. 11 REGULATOR

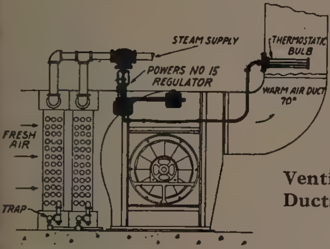


For Hot Water Heaters,
Feed Water Heaters,
Fuel Oil Heaters,
Drinking Water
Systems, Etc.

Write for
Bulletin No. 229

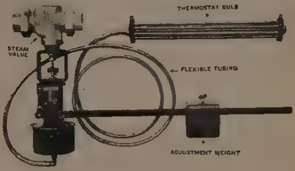


POWERS NO. 15 REGULATOR



For
Drying
Rooms

Ventilating
Ducts, Etc.



Write for Bulletin No. 238

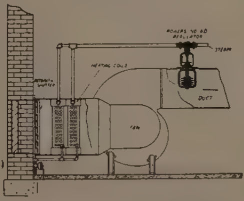
POWERS NO. 16 REGULATOR

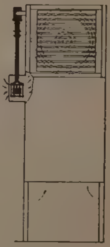
Style A

Style B

For
Unit Heaters

Ventilating
Ducts,
Brine Coil
Control, Etc.





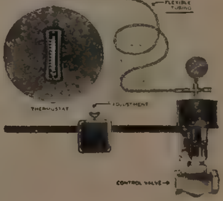
Write for Bulletin No. 246

POWERS NO. 18 REGULATOR

Installed on direct heating system in an office

For
Storage Rooms
Offices
and Factories

Write for
Bulletin No. 245



Minneapolis-Honeywell Regulator Company

Executive Offices
2711 Fourth Avenue, S., **Minneapolis**

Factories: Minneapolis, Minn. and Wabash, Ind.

Branch and Distributing Offices: New York, Chicago, Philadelphia, Boston, Detroit, Cleveland, Providence, Newark, St. Louis, Cincinnati, Milwaukee, Pittsburgh, Baltimore, Washington, D. C.; Buffalo, Syracuse, Rochester, N. Y.; St. Paul, Denver, Salt Lake City, Louisville, Los Angeles, San Francisco, Portland, Seattle, Hartford, New Haven, Springfield, Mass. In Canada: Halifax, N. S.; St. John, N. B.; Montreal, Toronto, Windsor, Winnipeg, Calgary, Vancouver. Agencies in almost every city.

Manufacturers of Temperature, Pressure and Safety Combustion Controls for all Types of Residence and Industrial Heating Systems, Including Oil Burners, Gas Burners, Coal Stokers, Automatic Blowers, District Steam and Single Unit Controls for Buildings. Service Departments Maintained by all Branch Offices and Agencies.

THERMOSTATS—Oil, Gas or Coal Heat Control

8-Day Clock Thermostats—give differential day and night temperature control for buildings unoccupied at night or where lower night temperatures are required. Types available for motor valve or relay operation.

Plain Thermostats (low voltage)—are used where one temperature is required at all hours or where irregular temperature regulation or group or master clock control is necessary. Available for motor valve or relay operation.

110 Volt Thermostats (Mercury Tube Contacts)—for use where accuracy of operation is not of primary importance, such as in garages, storage warehouses, etc. No transformers or relays are needed. Installation is low in cost.

Clock Thermostat

THERMOSTAT GUARDS—Fitted and locked over thermostats to prevent tampering with the setting or mechanism.

DUAL CONTROL UNITS—Dual Control offers protection against damage to heating plants due to overheating and gives a decided advantage from the standpoint of fuel economy and safety.

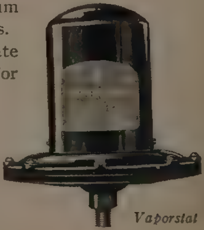
For Hot Water Heating Systems, the AQUASTAT provides more uniform room temperatures as well as protection against overheating of the boiler.

Aquastat

For Warm Air Systems, the MINNEAPOLIS-HONEYWELL WARM AIR LIMIT CONTROL, installed in the principal warm air duct for any limit up to 240 deg. fahr., gives overheating protection to warm air furnaces.

For Steam Systems, the PRESSURETROL, an enclosed contact mercury tube type steam boiler limiting device—simple, compact and sturdy—provides safety from overheating of boiler units and maximum fuel economy. Available for both low and high voltage circuits.

For Vapor Systems, the VAPORSTAT—designed to operate with vapor but will not control within the vacuum range. For additional safety protection in connection with room thermostats—gives extreme accuracy and maximum fuel economy. For low pressure vapor systems, shuts off fire when pressure increases a few ounces. May be used singly to control burner from the boiler temperature or in dual control with the room thermostat.


Vaporstat

PROTECTORELAY—Complete line for full automatic control of all types of oil burner installations. Available for 110 or 220 volts, 25, 30, 40, 50 or 60 cycle A. C. and 110 or 220 volt D. C. Listed as standard by Underwriters Laboratories, Inc.

GAS VALVES—Minneapolis-Honeywell electric gas valves for automatically controlling gas supply used directly in connection with thermostat. Gas valves for use in connection with Pyrostat or Protectostat also available. Provide positive operation at all times with safety combustion protection by the use of a thermal cutout switch. Available in sizes ¾, 1, 1¼, 1½ and 2 in.

Motor Gas Valve

COAL BURNING CONTROL—Electric motors for controlling heating plant dampers. Also controls for automatic stoker operation.

UNIT HEATER CONTROL SYSTEM—Minneapolis-Honeywell controls are designed to meet all types of installations from the cheapest direct line control by 110 volt thermostats to the complete control systems which can only be accomplished through the use of low voltage thermostats, motor valves and relays.

Plain Thermostat

The following are typical systems of Minneapolis-Honeywell control:

Unifan Control—the fan motor of a unit heater is controlled by temperature or pressure in the return line. Prevents operation of fan when heating coil is cold, eliminating cold blasts.

Operating Motor

Steam Flow Control—motorized valve in steam line operating from a low voltage thermostat—shuts off or turns on steam at demand of thermostat. Eliminates condensation losses during standby periods. Can be used in connection with direct radiation and hot water heating systems.

Motorized valves for steam flow control—consist of electric motors integrally mounted either above or below a semi-balanced globe type valve. Available for angle or straight through mounting up to and including six inches. For 110 or 220 volt D. C. or 110 volt or 220 volt, 25, 40 and 60 cycle A. C.

Steam Flow Control Valve

Plain Thermostat Control—for use principally where constant temperature is to be maintained 24 hours of the day.

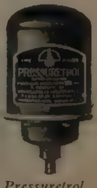
Direct Clock Control—for automatic night and day regulation of temperatures where a different temperature for each period is desired.

Unit Clock Control—for use where unit heaters in different locations of building are operated on different day and night basis.

Group Clock Control—for use where unit heaters are grouped under uniform conditions. Single clock type thermostat used to control the plain thermostats in all groups combined.

Master Clock Control—for automatic control of day and night temperatures in individual departments of plant. This independent control of sections permits re-establishment of daytime control by hand operated switch.

District Steam Supply—refers to control system where the steam supply is from a central station heating plant or the heating plant of the building itself and sectional or zone layouts are used.



Pressuretrol

PROMPT ATTENTION WILL BE GIVEN TO REQUESTS FOR CATALOGS ON THE COMPLETE LINE OF MINNEAPOLIS-HONEYWELL CONTROL EQUIPMENT

CRANE CO.

Manufacturers of Valves, Fittings, Fabricated Piping, Steam Specialties, Plumbing and Heating Materials

836 S. Michigan Avenue **Chicago, Ill.**

Branches in All Principal Cities

Write for catalogues and full information about any materials in which you are interested

No. 112 Low Type Radiator Valve

No. 112 Low Type Radiator Valve

The No. 112 valve is equipped with a Crane Renewable Radiator Valve Disc and is of the packed type. It performs all the duties of steam radiator service in an accurate and satisfactory manner and is adaptable to installations in homes, hotels and large buildings.

Forged brass stems, disc holders, tailpieces, tailpiece rings and packing nuts give this valve a substantial construction which combines fine quality with strength and reliability. A moulded composition handwheel eliminates the possibility of burned fingers. A liberal quantity of braided asbestos packing does away with frequent repacking of the stuffing box.

All wrench surfaces and points where strains occur have been made amply heavy in order to prevent breakage. The threaded bonnet connection is constructed so that there is no possibility of leakage or of stripping off. This valve is designed to withstand the effects of frequent temperature changes. The beautiful design and nickel finish of this valve will harmonize with the most attractive surroundings.

No. 438 Standard Brass Wedge Gate Valve

Wedge Gate Valve No. 438

This valve has been designed for general service and is recommended for use wherever brass gate valves for 125 lb. steam working pressure are desired.

The guides on the discs and the ribs in the bodies are accurately fitted, which insures true and easy movement, prevents wear of the faces and also prevents the discs from touching the seats in the bodies except at the point of closing. When wide open this valve may be repacked while under pressure.

No. 01 Oil Separator

Oil Separator No. 01
Sizes ½ to 10 in. incl.

An Oil Separator should be used in every steam plant where exhaust steam is used for heating. It will keep the oil out of the pipes and radiators, thereby preventing a loss of efficiency and eliminating the disagreeable odor of oil which is apparent when the air valves are opened.

The baffle plate inside the oil separator slows up the current of the exhaust steam and changes its direction of flow. The globules of oil impinging on the baffle follow its grooves down into the drip pocket, which is out of the flow of the steam.

No. 7 Union Bonnet Brass Globe Valve

The No. 7 Valve is recommended for steam working pressures up to 150 lb. and is designed for use in plants where discs must be changed quickly without injury to the valve. The Crane Renewable Disc is held in place in the disc holder by means of a brass nut, and the disc holder slips onto the stem and is accurately guided in the body of the valve by four guide wings.

To be able to make repairs quickly, users should keep on hand a supply of the discs and holders complete. The old disc may be removed and a new one placed in the holder at the convenience of the engineer.

Globe Valve No. 7

No. 460 Standard Iron Body Wedge Gate Valve

Wedge Gate Valve No. 460

This non-rising stem wedge gate valve belongs to our large and complete line of wedge and double disc gate valves. It is suitable for steam working pressures up to 125 lb. in sizes 16-in. and smaller and for 100 lb. in the 18-in. and larger sizes. Each valve is tested to 150 lb. hydraulic pressure with the valve closed, and at various times they have been subjected to hydraulic pressures of from 250 lb. to 500 lb., depending upon the size, without leaking.

The finishing and fitting of the guides on the disc and the ribs on the body is such that it insures proper movement of the disc and prevents wear of the disc faces; and in addition keeps the disc from touching the seats except at the closing point.

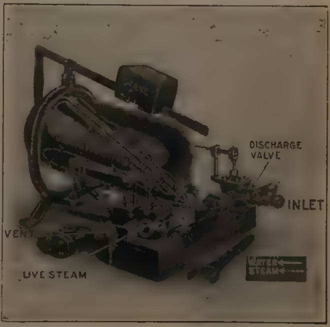
The construction is such that when wide open it may be repacked while under pressure.

No. 100 Cranetilt Three-Valve Lifting Trap

A steam trap is needed to prevent the escape of steam while removing condensation from all low points in steam piping, drip pockets, separators and steam-using appliances.

It is called a lifting trap because it is used when the pressure of the condensation is not great enough to force it from the trap to the point of delivery. The pressure to do this work is supplied from some outside source, usually a high pressure steam line, though it may be a compressed air line.

This trap is automatic in operation and its steam consumption depends entirely upon the work done. The movement of the tank is controlled by the water which comes to the trap, and when there is no water the trap automatically cuts off the steam consumption until water again accumulates in the trap tank.



Cranetilt 3-Valve Trap Series No. 100. Sizes ½ to 3 in. incl

The Direct Control Valve Company

8 South Michigan Avenue, **Chicago, Illinois**

Branch Offices

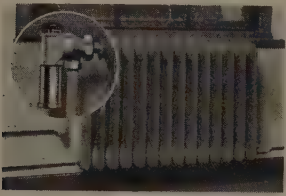
New York City
10 East 40th Street
Boston, Mass.
131 State Street
Newark. N. J.
972 Broad Street
Philadelphia, Pa.
111 South 15th Street
Washington, D. C.
910—17th Street, N.W.
Raleigh, N. C.
Atlanta, Ga.
Red Rock Building
Rochester, N. Y.
306 Laburnum Crescent
Huntington, W. Va.
Box 878

Pittsburgh, Pa.
1007 Diamond Bank Bldg.
Johnstown, Pa.
244 Market Street
Cleveland, Ohio
976 Union Trust Building
Columbus, Ohio
615 Joyce Realty Building
Mansfield, Ohio
136 Stewart Avenue
Warren, Ohio
24 Homwood Drive
Detroit, Mich.
2051 W. Lafayette Blvd.
Louisville, Ky.
St. Louis, Mo.
610 First Natl. Life Bldg.

Milwaukee, Wis.
Minneapolis, Minn.
1220 Foshay Tower
Des Moines, Ia.
2001 East 33rd Street
Waterloo, Ia.
111 Highland Blvd.
Oklahoma City, Okla.
120 E. Main Street
Little Rock. Ark.
Tulsa, Okla.
Seattle, Wash.
308 First Avenue, South
San Francisco, Calif.

DIRECT CONTROL VALVE

It is a thermostatically operated, hydraulic, quick opening, packless radiator valve, controlling the steam to the radiator so as to automatically maintain room temperature at any required degree.

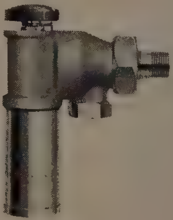


Self Contained Unit

The Direct Control Valve is a tried and perfected method of individual radiator control. It is a complete, self contained unit requiring no outside attachments or power of any kind. It is as easily installed as a hand valve. It costs only a fraction of the usual temperature control system. It automatically regulates the amount of steam to the radiator. The saving in fuel alone usually repays its cost in about 3 years.

It may be applied to any building, new or old, which is equipped with a two-pipe heating system—vacuum, vapor, or atmospheric steam.

The degree of temperature at which the room is to be maintained may be controlled by the occupant of the room. Or the valve can be equipped with a lock to be operated only by the building operator.



Advantages

Reduced Fuel Cost—Maintains constant, healthful temperature with large savings in steam and fuel. *The savings in fuel alone return complete installation costs together with interest on the investment in about 3 years.*

THE DIRECT CONTROL VALVE COMPANY

Low Maintenance Cost—There is practically no maintenance cost. The Direct Control Valve is a self contained unit requiring no outside accessories or attachments, no complicated piping systems, no delicate wall mounted thermostats. *The First Cost is the Last Cost.*

Low Initial Cost—It requires no more labor installation cost than an ordinary hand valve. The simplicity of design and the sturdy construction assures uninterrupted temperature control within the prescribed control limits with practically no upkeep costs. The valve is of all metal construction, guaranteed for 3 years, and built to give indefinitely long service.

Description

Thermostatic Unit—The thermostatic unit, 3½ in. long, is ruggedly built to withstand abuse. Utilizes hydraulic pressure for valve operation. Is positive and powerful, fulfilling test of 2500-3000 lbs. per sq. in. The hydraulic pressure is constant and effective. It is unaffected by evaporation or chemical change—once filled and sealed it remains in its original condition developing constantly the necessary power to firmly seat the valve.

Standard Type—Occupies a minimum of space. Height over all 7 in.

Sizes—Furnished in ¾, 1, 1¼, 1½ and 2 in. sizes.

Recessed Radiators—For concealed or recessed radiators, valves can be furnished with extension stems.

Specification

On each radiator, furnish and install a self contained thermostatic radiator valve, designed to control room temperature within one degree above or below a predetermined room temperature.

These values shall be actuated by means of hydraulic thermostat and shall be so arranged that each valve can be shut off by hand or not, as desired.

These valves shall be designed to control at an average room temperature of .... deg. fahr.

Valves shall be nickel plated finish and shall be of the following sizes:

For radiators up to 80 sq. ft. ¾ in. valve
For radiators 80 to 140 sq. ft. 1 in. valve
For radiators 140 to 250 sq. ft. 1¼ in. valve
For radiators 250 to 350 sq. ft. 1½ in. valve
For radiators 350 sq. ft. and above 2 in. valve

Standard Guarantee

The Direct Control Valve Company guarantees that a Direct Control Valve or Valves, when properly installed on sufficient radiation to properly heat the room, will maintain a room temperature within the limits of 1 deg. fahr. above and 1 deg. fahr. below the point of adjustment.

Write for catalogue showing all dimensions.

A Few Notable Recent Installations:

Chicago Civic Opera Building
Chicago

Rand Building
Minneapolis

New York Life Insurance Building
New York City

Fisher Building
Detroit

Koppers Building
Pittsburgh

Arnold-Constable Building
New York City

Willoughby Tower
Chicago

Reynolds Tobacco Co. Building
Winston-Salem, N.C.

Fuller Building
New York City

Foreman National Bank Building
Chicago

Grinnell Company, Inc.

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Executive Offices: **Providence, R. I.**

Exclusive Distributors of ThermOflex Traps and Other Heating Specialties

For complete data on other Grinnell Products, see pages 693-699

The heart of all ThermOflex Traps is the Hydron Bellows.

The Hydron bellows is formed under hydraulic pressure. This powerful internal pressure locates any weakness of any nature in the tubing. Such hydraulic pressure is many times more severe than any pressure the Trap will ever be called upon to control. Every ThermOflex Trap, therefore, is practically indestructible.

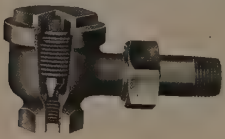
ThermOflex Traps have an exceptionally large orifice. This large orifice combined with high lift, insures fast action and freedom from clogging.

We supply ThermOflex Traps guaranteed for steam pressure up to 125 lb. Complete information and details of typical installations will be gladly sent on your request.

Valves, Traps, Gauges, Etc.

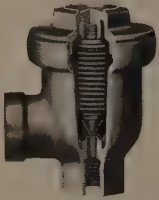
The ThermOflex line includes, Radiator Traps, Offset Traps, Blast Traps, Drip Traps, High Pressure Traps, Vent Traps, High grade Packless Inlet Valves, Automatic Boiler Feeders, and the ThermOflex Alternator, ThermOflex Compound Gauge, ThermOflex Damper Regulator.

No. 12
ThermOflex Radiator Trap



The full eight-fold ThermOflex-Hydron Bellows is the best bellows ever made. Because of the Hydron-forming process every bellows is absolutely perfect. Body is extra heavy throughout, using a brass forging for the cap and spudnut, highest-grade cast brass for the body and spud. The No. 12 is made in angle pattern only, with ½ in. inlet and ½ in. outlet tappings. The inlet neck is double thick to allow for expansion strains.

ThermOflex High Pressure Traps



The No. 100 ThermOflex Hydron Trap is guaranteed for steam pressures from 0-125 lb. Must not be used where the steam temperature exceeds 400 deg. fahr.

For use in all types of process work, Laundry Machinery, Kitchen Equipment, Hospital Sterilizers, Vulcanizers, Dry Kilns, Unit Heaters, Street Steam Service, etc., in fact any place that a trap is desired for service at the above pressures.

Small, compact and inexpensive in comparison to the usual float or bucket trap.

Extra heavy cast brass body without unions with renewable monel metal seat in body. Valve on bellows is of nitrided steel which cannot rust and will not score or wire draw.

Regularly furnished without unions plain brass finish. Can be furnished nickel or chromium plated at extra cost.

No. 4 ThermOflex Drip Traps

For dripping mains, risers, coils and unit heaters, we offer this type of trap. Cast-iron body, brass cap and inserted brass seat, angle pattern only, without unions. Can be used for any general purpose where a finished, nickel-plated trap is not necessary, and at a lower cost.

The Fairbanks Company

New York, N. Y. Boston, Mass.
Pittsburgh, Pa. London, England

Factory: **Binghamton, N. Y.**

Fairbanks Bronze Globe Valves

Simple in construction; parts quickly and easily renewed; stuffing box packed with specially moulded vulcabeston ring which is durable and cannot be blown or washed out; valves can be packed under pressure when wide open. Made in sizes ⅛ to 3 in.

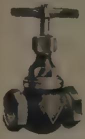


Fig. 01

Fairbanks Bronze Radiator Valves

Globe and Angle Types

Embody all good points of the Fairbanks Fig. 01 Valve. Furnished with Wood Wheels or lock shield and T handles. Made in sizes ½ to 2 in.

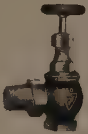


Fig. 012

Fairbanks Standard Bronze Gate Valves

For general service. Stuffing boxes can be repacked under pressure when wide open. Guides in wedge and ribs in body so fitted as to insure true and easy movement; prevent wedge from touching seats except at point of closing. Made in sizes from ¼ to 3 in.

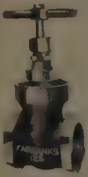


Fig. 0205

Fairbanks Bronze Swing Check Valve

As perfect a check valve as ever constructed. Has full area equal to pipe connection and straightway passage. The rotating disc works freely, never sticking on the seat. Made in sizes ¼ to 3 in.

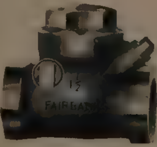


Fig. 0601

Fairbanks Iron Body Valves

Globe and Angle Types with Renewable Vulcabeston Ring Disc

Embody the most modern renewable features. Have a raised round seat upon which scale, grip or other sediment will not lodge. Disc Rings will not crack or flake; easily and quickly renewed. Valve so constructed as to eliminate all rattling or tilting when open.

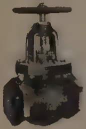


Fig. 0101

Fairbanks Standard Iron Body Gate Valves

Designed for a maximum steam working pressure of 125 lb. Guides in wedge and ribs in body so finished and fitted as to insure true and easy movement; prevent wedge from touching seats in body, except at point of closing. Made in sizes from 2 to 12 in. Flanged type up to 20 in.

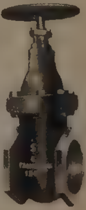


Fig. 0402

Fairbanks Iron Body Swing Check Valves

Designed with a 45 deg. Angle seat making it possible to use the valve in either a horizontal or a vertical position. Regularly equipped with Bronze Disc; can be furnished with Rubber Disc for water service. Made in sizes 2 to 12 in.

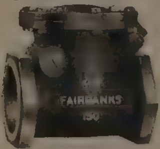


Fig. 0701

Fairbanks Sphero Ball Valves

An entirely different principle,—designed and built to meet the need of an easily operated, quickly repaired valve. Construction is simple and substantial. Has straight through passageway, renewable seats, interchangeable parts, and is easily opened or closed. Made in sizes from ½ to 8 in.

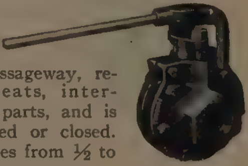


Fig. 0828

Marsh Valve Company

Plant and General Offices: DUNKIRK, NEW YORK

General Sales Distributors

Edward T. Hetherington
1709 Sansom Street, Philadelphia, Pa.

United States Radiator Corporation
General Offices, Detroit, Mich.

Taylor-Forbes Company
Canadian Agents, Guelph, Ont.

Appleton & Liptrott, Inc.
1480 Broadway, New York

John W. Mabbs
431 S. Dearborn Street, Chicago, Ill.

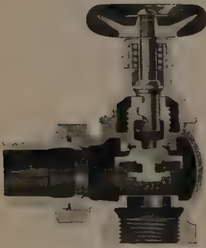
Sarco Company, Inc.
183 Madison Avenue, New York

We specialize on high-grade Radiator Valves and make the largest line of any company in the world.

The re-enforced packless feature of our Packless and Modulated lines both steam and water and the upper seat features of our Union Bonnet, Special and Gate lines are distinctive, scientific, mechanical principles, used with these lines exclusively.

MARSH RE-ENFORCED PACKLESS RADIATOR VALVES

Oval Wheel or Lock Shield



Flat-Disc

All sizes and

patterns

Globes, Angles

Corner and

Back Offsets

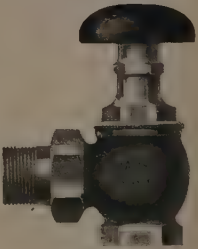


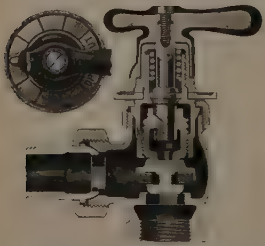
Fig. 133

We call particular attention to the scientific mechanical construction of the Re-enforced Cone Metal Packless Feature of our Modulated and Packless Valves. These are the only Packless Valves in which the Packless feature is re-enforced or in any way protected against leakage due to wear or cracks of so-called Packless parts and are GUARANTEED against wear or defects of Packless construction and leakage through bonnets.

QUICK OPENING

A three-fourths turn will fully open a ¾ in. valve, and from this up to one and one-quarter turns for balance of line through 2 in. These valves, account of low pitch of thread due to large diameter of cylinder, will seal and lock against any pressure.

MARSH RE-ENFORCED MODULATED LEVER HANDLE RADIATOR VALVES



Flat-Disc

These Valves

may be had with

Oval Wheel

in place of

Lever Handle

same as Fig. 147

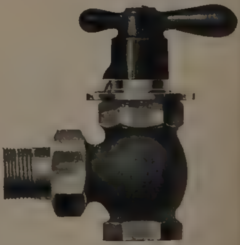
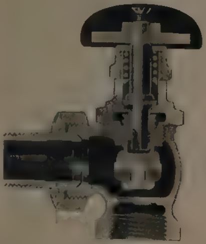


Fig. 132

The Modulation or Graduation is accomplished by a cone disc nut, regulating volume of steam, according to pressure, until indicator registers valve about two-thirds open, when the further turning of lever handle until indicator registers open, will give full valve capacity; a feature of material value in a valve in which volume or capacity for modulating purposes is choked down, and to meet extreme weather conditions, full pipe capacity is required.

MARSH RE-ENFORCED PACKLESS CONE DISC RADIATOR VALVES

Oval Wheel or Lock Shield



Cone-Disc

These Discs will not crack or leak through valve seat.

No clogging or water hammer from return condensation

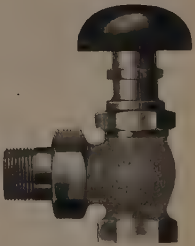
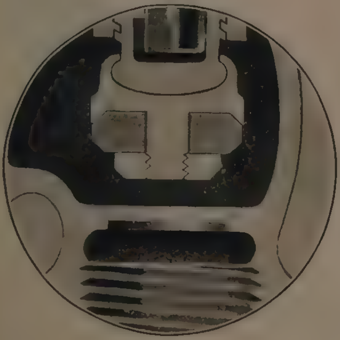


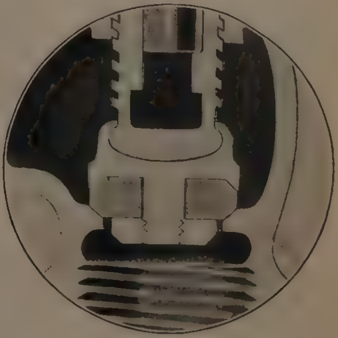
Fig. 141

Marsh Cone Discs are without question one of the greatest improvements in radiator valve construction in the past fifty years or since the composition disc replaced the old style metal-to-metal disc and seat.

This Cone Disc construction combined with the Marsh Re-enforced Packless Feature is the last word in completing radiator valve maximum efficiency at popular price, all of which will check 100 per cent true upon investigation.



¾ in. Full Size



Positive Seal

The above views showing cone disc and beveled seat are to actual size of a ¾ in. valve and are made to full size to show the following advantages of this construction over the old style flat disc and seat:

First: Through design of disc and protection afforded from disc nut covering under surface they will not warp and crack as will a flat disc which overhangs valve seat.

Second: The compression is at right angles to face of seat, forcing disc compound inward to center, making disc more compact and harder instead of scoring and extruding over seat, opening cracks or seams if any, as with a flat disc.

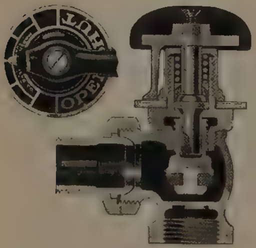
Third: While the life of these cone discs because of construction, as proven by tests, is three to five times the life of a flat disc, and a CRACKED DISC IS IMPOSSIBLE, the matter of exchange if desired is very simple, as to remove disc nut the disc will drop from disc-holder, while with a flat disc it must be dug out, often destroying disc-holder. Further, these cone discs are reversible and can be turned over or replaced with new at the same cost as for a flat disc.

Fourth: The beveled seat is low in valve body, giving complete drainage and will wash free from sand or scale in system, positively providing against leakage through scale or grit imbedding in disc AS IS COMMON with a raised flat seat and flat disc construction.

Fifth: Through this low beveled seat, to return condensation through valve for a one-pipe system, the flow will hold to the outer wall leaving center of valve throat and pipe free rather than shoot out over a raised seat to the center of pipe as is common with a heavy flow over a flat seat, clogging flow of steam, causing hammer or pounding of system.

The foregoing are all, each and every one, practical points which will prove out in test and practice.

MARSH RE-ENFORCED MODULATED CONE DISC RADIATOR VALVES



Cone-Disc Mod.

Oval Wheel, Lever Handle or Lock Shield

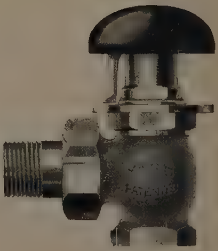


Fig. 147

The Modulation feature of our Cone Disc Line is the same as with our union bonnet flat disc Fig. 132.

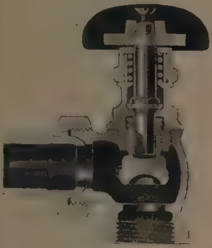
Our Cone Disc Modulated valves unless otherwise ordered are fitted with Oval Wheel. When Lever Handle is preferred, Fig. No. is 148.

With our Oval Wheel Handle user has the same dial and indicator control as with Lever handle and a much stronger and more serviceable CONSTRUCTION than is possible with a Wood wheel as this composition won't break or split as will wood.

Further, this wheel is removable and interchangeable with our Lever handle, effecting a material advantage to customer in matter of convenience of changing from one to the other on job if for any reason change is desired.

MARSH RE-ENFORCED PACKLESS WATER RADIATOR VALVES

Oval Wheel or Lock Shield



Packless

A Genuine Packless Water Valve Guaranteed to hold any pressure required for forced circulation

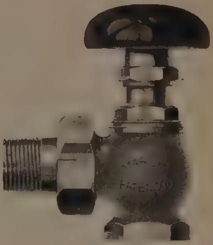


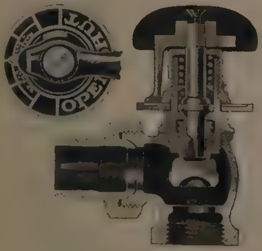
Fig. 137

Marsh re-enforced packless Hot Water Radiator Valves are not only a boon but the answer to hot water heating problems, permitting the same ease of operation and complete temperature control as with steam.

These hot water valves are quick opening, can be operated—opened and closed—with perfect ease by a child and will not stick or leak.

They will hold high pressure suitable for forced circulation up to any pressure radiation will stand, and the cost is nominal.

MARSH RE-ENFORCED GRADUATED WATER RADIATOR VALVES



Water Graduated

Oval Wheel, Lever Handle or Lock Shield

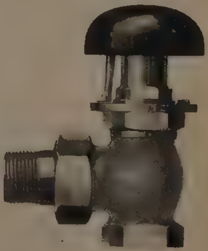


Fig. 139

SOMETHING ENTIRELY NEW IN WATER HEAT REGULATION

We have made a special study of hot water heat regulation and control and are pioneers in the matter of individual radiator control, through a graduated valve, employing the same principle as with steam. If you can modulate, graduate, or regulate individual radiator vapor or vacuum steam heat through a valve (and you can), then why not by the same principle regulate water heat, and, for that matter more consistently than steam, as with water you have something to regulate, while with steam, to allow fire to drop below a given point, you have nothing.

For sleeping rooms, heat regulation with the Marsh Graduated water valves may be controlled with the same ease of operation and certainty of results as is possible with a Modulated valve on a steam system, and at a much less cost than for a vapor or vacuum system installation.

Further, water circulation for each radiator, graduating for same or balancing of system, can be increased from nothing to full pipe capacity and held or locked at any intermediate point, if desired, by simply turning dial so that stop on same will register against indicator or pointer and locking dial in this position, preventing further opening of valve or turning of wheel or lever handle to the left.

These valves cost but little more than our regular water valves and much less than steam modulated valves.

Jenkins Bros.

Manufacturers of Valves and Mechanical Rubber Goods

Principal Stores and Offices

80 White Street
NEW YORK, N. Y.

524 Atlantic Avenue
BOSTON, MASS.

133 North 7th Street
PHILADELPHIA, PA.

646 Washington Boulevard
CHICAGO, ILL.

FACTORIES IN ELIZABETH, N. J. AND BRIDGEPORT, CONN.

JENKINS BROS., LIMITED

CANADIAN WORKS AND HEAD OFFICE: MONTREAL, QUE., 617 St. Remi Street
LONDON OFFICE: 6 Great Queen Street, Kingsway, W. C. 2

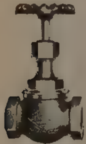


Fig. 106
Bronze Globe, Screwed

PRODUCTS

Jenkins Globe, Angle, Cross, Check, Hose, Blow-Off, Safety and Gate Valves; Radiator Supply Valves. Also, Rapid Action Valves; Steam Traps; Gage Cocks; Marine Valves, Needle Valves—Valve Discs; Jenkins '96 and Jenarco Sheet Packing, Gaskets, Pump Valves; Compressed Asbestos Joisting; and Moncrieff Scotch Gauge Glasses.

Renewable Disc, Bronze and Iron Body Valves, Standard Pattern

Jenkins Valves, standard pattern, all have the feature of renewable disc and disc-holder. The renewable disc, first introduced by JENKINS BROS. many years ago, assures absolute tightness. The flexibility of the Jenkins disc secures perfect seat contact and is a most important improvement in valve construction. For steam use, the discs are made of hard composition, which becomes pliable under the action of steam; for water, gas and air service, somewhat softer compounds are furnished.

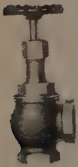


Fig. 108
Bronze Angle, Screwed

Radiator Valves

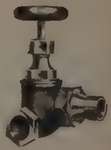


Fig. 180
Bronze Offset Corner. Radiator with Union

Regularly furnished with black composition wheels, or, if desired, with bronze, wire or iron wheels. Furnished in the new low-bonnet patterns or the regular pattern as supplied for years.

Lock shield valves, to be operated with key, designed to prevent tampering, can be supplied in all the different patterns.

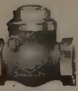


Fig. 352
Bronze Swing Check Valve

Corner valves are made in two patterns—regular and offset. Regular styles of finish follow:

Rough body, finished trimmings, No. 1 screwed, No. 6 with union.

Finished and polished all over, No. 2 screwed, No. 7 with union.

Rough body, nickel-plated trimmings, No. 3 screwed, No. 8 with union.

Rough body, nickel-plated all over, No. 4 screwed, No. 9 with union.

Finished and nickel-plated all over, No. 5 screwed, No. 10 with union.

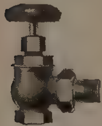


Fig. 853
Low Bonnet Radiator Angle, Male Union

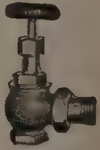


Fig. 168
Radiator Angle, with Union

Catalog

A catalog of all the Jenkins valves, giving sizes, styles and list prices, mailed on request.

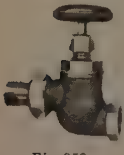


Fig. 859
Low Bonnet Radiator Offset Globe, Male Union

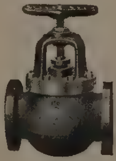


Fig. 142
Iron Body Globe, Flanged

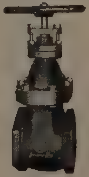


Fig. 325
Iron Body Gate, Screwed

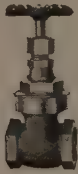


Fig. 370
Bronze Gate, Screwed

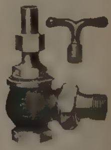


Fig. 170
Bronze Lock Shield Radiator Angle, with Union

New York Air Valve Corporation

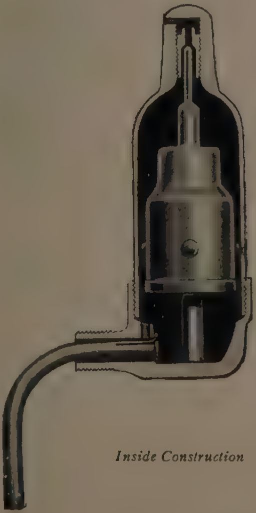
476-478 Broome Street
New York

THE "AIR-OUT" LINE

SYPHON **THERMOSTATIC** **NON-ADJUSTABLE**

"Air-Out" valves, for eliminating air from steam radiators, operate by the expansion of a phosphor bronze diaphragm, soldered on the bottom of a brass float, containing a volatile liquid. This float is large in size, allowing ample capacity for the necessary pressure to operate the diaphragm.

The seating pin at the top of float is made from nickel silver, as called for in United States Government specifications for Air Valves. Verdigris will not form on nickel silver—corrosion at the vent post is therefore reduced to a minimum.



Inside Construction

We do not use a "stamped out" base. Our bases are heavy bronze castings, in one piece, with no soldered parts to break off.

Made also in straight pattern, threaded ⅛, ¼ and ¾ in. for quick venting of cellar mains and risers.

The best valve money and experience can produce and sold at reasonable prices.

OTHER SPECIALTIES

Carbon Post Automatic Air Valves.
Key and Wood Wheel Air Valves.
Adjustable Floor and Ceiling Plates.
Steam and Altitude Gauges.
Water Gauges.
Pop Safety Valves.

"Air-Out" Valves Guaranteed for Five Years

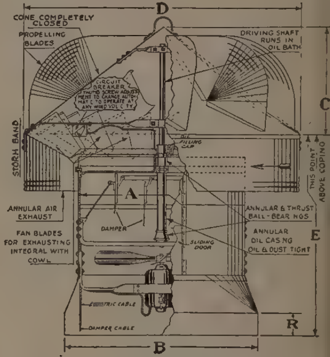
W. F. Hirschman Co., Inc.

Main Office: Buffalo, N.Y. **Works: Le Roy, N.Y.**
New York, N. Y., 205 East 42nd Street Boston, Mass., 37 Pearl Street Detroit, Mich., 97 W. Warren Ave.
MANUFACTURERS ROOF VENTILATORS

Principle of Operation of Wind-Electric Ventilator—When the wind is blowing sufficiently to remove the desired amount of air from the building being ventilated, the electric motor is still. Instantly, when the wind turbine moves below a previously determined number of revolutions, the electric motor starts automatically and carries the load. The entire apparatus is noiseless.

Special Advantages—Besides the regular automatic operation the motor may also be so connected as to give a maximum exhaust capacity (running full speed) by manual control.

Effico Rotary Ball Bearing Ventilator Installation, Wind Driven (only) The Effico Wind Electric Also Has the Same Artistic Lines and Pleasing Appearance. Lowest in Height of Rotary Ventilators by Over 50 per cent Average.


D
CONE COMPLETELY CLOSED
PROPELLING BLADES
DRIVING SHAFT RUNS IN OIL BATH
CIRCUIT BREAKER THUMB SCREW ADJUSTMENT TO CHANGE AUTOMATIC TO OPERATE AT ANY WIND VELOCITY
C
STORM BAND
OIL FILLING CAP
THIS POINT ABOVE COPING
A
ANNULAR AIR EXHAUST
ANNULAR & THRUST BALL-BEARINGS
DAMPER
FAN BLADES FOR EXHAUSTING INTEGRAL WITH COWL
ANNULAR OIL CASING OIL & DUST TIGHT
E
SLIDING DOOR
ELECTRIC CABLE
DAMPER CABLE
R
B

Detail of Effico Wind Electric Rotary Ball Bearing Ventilat Full Automatic

Note.—Details of Wind Driven (only) Ventilator are Identical with Exception of Motor Unit.

CAPACITIES OF EFFICO ROTARY BALL BEARING VENTILATORS

Both Wind Electric and Wind Driven (only)—Cubic Feet of Air Exhausted per Minute

Wind Velocity, Miles per Hour	*Bold Type is Regularly Furnished Wind-Electric Capacity*											
	Temperature Difference in Degrees Fahrenheit in Building and Outside											
	0	10	20	30	0	10	20	30	0	10	20	30
	12-In. Ventilator				18-In. Ventilator				24-In. Ventilator			
5	350	**440**	515	560	600	**850**	950	1040	1020	**1600**	1780	1900
10	430	525	600	625	910	1050	1200	1300	1490	1900	2100	2300
14	480	600	635	700	1050	1200	1300	1400	1800	2230	2460	2590
	30-In. Ventilator				36-In. Ventilator				42-In. Ventilator			
5	1560	**2300**	2690	2900	2300	**3400**	3810	4100	3150	**4500**	5010	5500
10	2300	3210	3490	3600	3250	4200	4720	5050	4390	5700	6300	6800
14	2900	3650	3850	4020	4040	4800	5300	5600	5600	6700	7400	7800
	48-In. Ventilator				54-In. Ventilator				60-In. Ventilator			
5	4000	**5900**	6700	7400	5100	**7300**	8450	9500	6500	**9300**	10600	11900
10	5900	7900	8900	9050	7850	9900	11000	11500	9200	12500	14000	14500
14	7000	9000	10000	10500	9500	11800	12500	12800	11400	14000	15000	16000

Effico Wind Electric Ventilator Dimensions

Ventilator Sizes Corresponding to Those in Table Opposite	Dimensions in Inches—(See Diagram Above)					Thickness of Metal			Hp. of Motor
	A	B	C	D	E	Gauge G. I.		Copper, Oz.	
	Actual Size of Ventilator for Wind Elec. Type	Base	Height of Blades	Diam. of Storm Band	Height to Propeller Blades	Cowl	Base		
12	14	20	8	21¾	32	24	22	16	1/30
18	19	26	10	28½	32	24	22	18	
24	25	38	14	40	40	24	20	18	
30	31	40	14	50	42	24	20	20	
36	37	44	18	60	45	22	18	24	1/6
42	43	50	22	68	51	22	18	24	
48	49	56	24	76	51	22	18	24	1/4
54	55	62	24	86	51	22	18	24	
60	61	66	24	98	55	22	18	24	

This apparatus is adjustable to exhaust various quantities of air within the limits of given sizes and is regularly supplied at capacities of 5 miles per hour wind and 10 deg. temperature difference rating. *The Wind-Electric will exhaust minimum volume regardless of temperature difference or wind velocity.* Other capacity can be supplied and the ventilator is adjustable to any constant capacity after installation.

Effico Wind-Electric Ventilator, Automatic

Patented May 20, 1922; March 20, 1928; August 21, 1928.

The Effico Wind Electric Ventilator, Full Automatic

Recommended for those installations which require a definite minimum exhaust at all times or which may require an unusually heavy exhaust at intermittent periods. This is the regular Effico equipped with an auxiliary electrically operated fan placed in the throat just below the regular fan. The throat is slightly enlarged to allow for the motor.

For F Electric Ventilator Non-Automatic see second page following:

"Effico" Wind-Driven Roof Ventilators

The Effico Ventilator consists of a wind-driven head to which suction blades are permanently connected (on the underside) making an efficient exhaust fan. Rotation of the head creates an exhaust suction in the throat of the ventilator. There are no moving parts.

Bearings.—Effico Bearings are full ball bearings, are solidly enclosed and oil-flooded (also dust and acid proof). They are as sturdy as the best automobile bearings, and will run in a dry state for years, but we oil-flood them as an extra precaution.

Effico Internal Louver Unit Ventilators

The Effico internal louver unit comprises the Effico rotary ball bearing ventilator head constructed with a specially short base, or neck. In this base is built a circular multiple blade louver damper. The damper is carefully balanced and heavily constructed. The blades lap and are fitted in a circular frame. It is adaptable for manual control, but is intended for a thermostatic control system. The roof base is very low, is part of this unit and is supplied with either the square or round base.

The roof base and the ventilator head are connected by means of angle iron companion rings, which give solidity and facilitate the taking down of the ventilator when required. Each ventilator neck has also a tight fitting door to give free access to the louvers and to the operating motor. The operating motor is suspended underneath the damper to a cross brace. The object of the specially low base and the low roof base is to make the entire unit as low to the roof as possible.

Effico Louver Dampers

Made of stretcher leveled sheet steel. The pneumatic damper motor is supplied and installed with these units unless not desired. (Note specifications below).

Effico Louver Unit

Low Height. The Effico louver unit sets very low (note dimensions at right).

Height above Coping

Louver Unit "C" dimension should be above coping. Note above.

Heads Only. Effico Heads without dampers are also supplied.

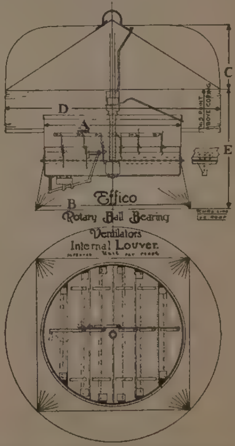
Suggested Specifications

The roof ventilators shall be of the sizes as shown in plans, [square base] [round base] style to be made of [Tuncan] [Copper]. [The pneumatic damper motor to be supplied with these units]. They shall be the Effico Internal Louver Unit Ventilators as manufactured by the W. F. HIRSCHMAN CO., INC., Buffalo, N. Y.

Effico Louver Unit Sizes and Dimensions

Dimensions, Inches					Galvanized Steel			Copper, Oz.	Code for Telegraphy
					Gauge		Net Wght., Lb.		
A	B	C	D	E	Cowl	Base			
18	20	10	28½	23	24	24	90	16	vale
24	30	14	40	30	22	22	140	18	valet
30	36	14	50	32	22	20	190	20	vive
36	42	18	60	32	22	18	225	24	varve
42	48	22	68	43	22	18	350	24	vetch
48	54	24	76	43	22	18	400	24	vax
54	60	24	86	43	22	18	600	24	vaid
60	66	24	98	43	20	18	710	24	valor
66	72	30	103½	49	20	18	800	24	vamp
72	80	30	114	54	20	18	880	24	vane
84	92	36	130	54	18	16	1050	24	vang
96	116	45	153	54	18	16	1200	24	van

For round bases, "E" dimension remains the same.
For capacities note preceding page.



Patented May 20, 1922; March 20, 1928.

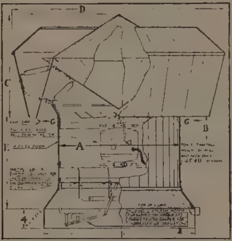
Open *Closed*

The Multiple Circular Louver Damper in Neck of Ventilator

CAPACITY—Exhaust capacity same as Effico Head—note opposite page, for F Electric Ventilator see next page.

Hirschman's S E and F Roof Ventilators

For our Effico Ventilator see preceding pages



F Electric Ventilator Non-Automatic (Patented)

Motor—Condenser Motor, Brushless, Cummutatorless, Variable Speed, fully enclosed, very quiet running, are furnished at extra cost when above characteristics are essential.

Recommendation of F Electric Ventilator—Is a high class ventilator where a high exhaust velocity is required at certain periodical times or resistance (static pressure) is encountered. Where our **Effico** Rotary Head, or the **Effico** Wind-Electric Automatic Ventilator, due to obstructed location or its moderate, even capacity is not required, then we recommend the Hirschman F Ventilator.

Dampers—Chain, pneumatic or electrically operating; close fitting damper supplied with all sizes if required. Fire Damper—with fusing link furnished if required. **There are no outside louvers to freeze or blow shut.**

As an Exhaust Head

FOR EXHAUST FAN

SE Ventilator design is such that air driven 1200 ft. velocity through the head, registers only .015 water gauge static pressure a performance of unequalled merit. Thus for a fan or high heat exhaust head, it is highly effective. When so used and the fan is cut off the ventilator still ventilates as a syphon ventilator. **There are no shutters to blow or freeze shut.**

Is also vision-proof, will resist back drafting during a five mile wind against an adverse temperature difference of 10 deg. fahr. Also during the same wind velocity will not back-draft unless a greater than static pressure resistance of .025 water gauge. For information on wind pressure causing down draft in the angle of U or L buildings, write us.

DIMENSIONS OF HIRSCHMAN F, SE AND LU VENTILATORS

Vents S E Weight Crated	Dimensions, In. (See Diagram)							Thickness of Metal			
	A	B	C	D	E	F	H	Ga. Galvan.		Oz. Copper	
								Head	Base	Head	Base
30	12	6	10	22	24	16	12	24	24	16	16
50	18	6	16	32	24	24	12	24	24	16	16
75	24	8	21	42	30	30	12	24	24	16	16
110	30	8	27	52	30	36	18	22	20	18	20
150	36	10	33	62	30	42	18	22	18	20	24
200	42	10	38	71	30	48	18	20	18	20	24
300	48	12	42	81	36	54	18	18	18	20	24
360	54	12	46	91	36	60	24	18	18	20	24
420	60	12	60	102	36	66	24	18	16	24	24
490	66	16	66	102	36	72	24	18	16	24	32
520	72	16	70	120	36	78	24	18	16	24	32
600	84	16	76	120	36	92	24	18	16	24	32

For utilizing heads only use "C" and "B" dimensions.

CAPACITIES OF HIRSCHMAN F VENTILATOR

Size of Stack, In.	Speed R.p.m.	Cu. Ft. Min. Less Than 1/8 in. Sp.	Cu. Ft. Min. 1/4 in. Sp.	Cu. Ft. Min. 3/8 in. Sp.	Type of Motor	H.P.	Telegraph Code
12	1425	650	....	....	T.D.	1/30	Range
	1750	900	....	....	S.R.	1/25	Ram
18	1140	1600	....	....	S.R.D.	1/25	Rone
	855	1675	900	....	S.D.R.	1/8	Rank
	1140	2000	1350	....	S.D.R.	1/6	Rap
	1420	2200	1600	1200	T.Q.	1/6	Raze
24	780	2600	1700	900	S.T.D.Q.	1/6	Ray
	850	3400	2600	1400	D.S.R.	1/4	Rat
	570	4000	3000	2100	S.T.	1/3	Rash
	1140	4500	3700	3200	S.D.R.	1/2	Rugn
30	680	4500	3600	2700	D.Q.	1/4	Rein
	900	6000	5000	3600	S.R.T.	1/2	Rinse
36	550	6500	5200	3900	S.R.	1/2	Rime
	900	7000	6000	5000	T.Q.D.	1/2	Rip
42	575	11000	8000	6500	S.T.Q.R.D.	3/4	Roar
	490	10000	7000	5000	S.T.R.Q.D.	1	Roast

Prefix letters in motor column indicate kind of current for which the motors are available.

Alterating—S, single-phase, 60 cycle. R, two or three-phase, 60 cycle. T, single-phase, 25 cycle Q, two or three-phase, 25 cycle. D, direct current.

The low speeds are suitable for schools, theatres, auditoriums and other quiet running requirements.

SE Ventilator

For industrial installations permitting increased speeds, capacity can be increased 100%

REMEMBER—With the Hirschman F Ventilator you still have a good ventilator when the motor is not running.

The Swartwout Company

Swartwout Rotary Ball Bearing Ventilators

18551 Euclid Avenue
Cleveland, Ohio

Branch Offices:
New York, N.Y., 103 Park Ave.
Pittsburgh, Pa., Grant Bldg.
Chicago, Ill., 549 W. Randolph St.
St. Louis, Mo., 1124 Chemical Bldg.

PRODUCTS—

Swartwout Rotary Ball Bearing Ventilators.

Construction—Swartwout Rotary Ball Bearing Ventilators are built of Armco Ingot Iron or special metals as required. All joints are double seamed—no bolts being used. All interior members are given a special rust-resisting coating after punching and forming.

Bronze bearings revolving on bronze balls provide free rotation without the necessity of lubrication. Outside louver dampers are controlled easily from within the building by a special louver attachment which permits definite setting of area opening without necessity of fastening the chain. Bases to fit standard sizes are made of the same metal, two gauges heavier than the ventilator.

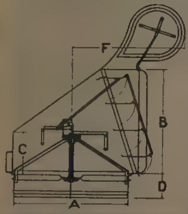
Erection and Operation—Swartwout Rotary Ball Bearing Ventilators leave the factory completely assembled.

Swinging freely with the wind, Swartwout Ventilators provide a continual suction of air from within the building.

Survey Service—The Swartwout Company co-operates with heating and ventilating engineers by making helpful recommendations in the form of Swartwout Surveys. There is no charge for this service.

Write for a copy of "The Gospel of Fresh Air," a new book on ventilation.

Dimensions, Weights and Gauges of Swartwout Ventilators



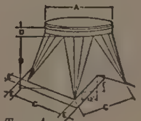
For dimensions, "A," "B," "C," "D," "F," in inches see table below.

In ordering only dimension "A" is required.

Installation

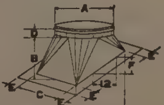
To insure proper installation and immediate satisfaction, complete directions for mounting are supplied on each ventilator.

A	B	C	D	F	Gauge Iron	Wt. Copper, Oz.	Net Wt., Lb.	Crated Wt., Lb.
10	9 1/8	4	5	11 1/2	24	18	15	20
12	11	4 3/4	5	14 1/4	24	18	20	25
14	12 7/8	5 3/4	5 1/2	15 1/2	24	18	30	30
16	14 3/4	6	5 1/2	17	24	18	35	40
18	16 1/2	6 3/8	6 1/2	19	24	18	45	55
20	18 1/2	7 9/16	6 1/2	21	24	18	50	65
24	22	9	6 3/4	24 1/2	24	20	60	80
30	27 1/2	11 5/16	9 1/8	30	22	24	120	175
36	33	13 1/2	11	34 1/2	22	24	160	240
42	38 1/2	15 3/4	11 1/4	41 1/4	20	28	225	390
48	44	18 7/8	11 1/4	46 1/2	20	28	320	465
54	49 1/2	20 1/4	13 3/4	47	20	28	485	690
60	55	22 1/2	15 1/2	61	20	28	560	750
66	60 1/2	24 3/4	16 3/4	62 1/2	20	28	650	825
72	66	27	16 3/4	67 1/2	20	28	780	1000

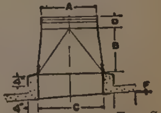


Type A

Dimensions, Weights and Gauges of Swartwout Bases



Type B



Type C

A	B	C	D	E	F	Gauge Iron	Wt. Copper, Oz.	Aver. Net Wt., Lb.	Aver. Crated Wt., Lb.
10	18	14	5	5	Required Dimension Slope per Foot	22	24	13	15
12	18	16	5	5		22	24	18	20
14	18	18	5	5		22	24	26	28
16	18	20	5	5		22	24	35	37
18	18	22	5	5		22	24	38	40
20	22	24	5	5		22	24	45	50
24	22	28	5	5		22	24	55	65
30	22	34	5	5		20	28	80	95
36	22	40	5	5		20	28	95	110
42	22	46	5	5		18	32	105	125
48	22	52	5	5		18	32	115	135
54	22	58	5	5		18	32	125	150
60	22	64	5	5		18	32	140	165
66	22	70	5	5		18	32	155	185
72	22	76	5	5		18	32	170	200

The Bastian-Blessing Co.

240 E. Ontario Street, **Chicago, Ill.**

Welding and Cutting Equipment

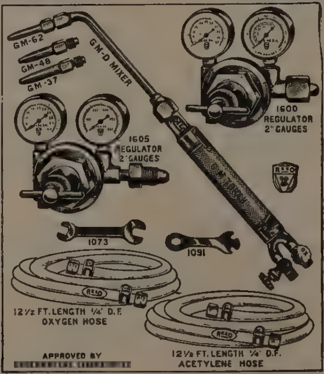
Welding is the modern way of making pipe joints, and this process is rapidly gaining the support of engineers and architects who recognize its superior qualities. With properly welded joints where threads are usually used the following results may be expected:

1. Increased efficiency in flow.
2. Increased tightness and leak-proofness of joint.
3. Rapid erection and easy alteration.
4. Less dead weight.
5. Decrease in first cost and in cost of upkeep.

The most modern skyscrapers have welded piping throughout. A fund of information is available for the asking. Write and state your problems.

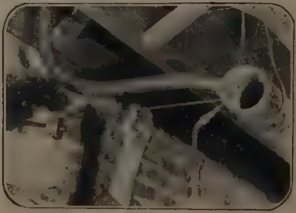
Welding School

Cutting New Opening



Complete units for both welding and cutting of pipes may be had for as low a price as $75.00 Our complete catalog will be sent on request.

Less Expensive Covering



Welding In Branch

Index to Modern Equipment

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS GUIDE, 1930

ACCESS PANELS (*See Panels, Access*)

AIR CLEANING EQUIPMENT
American Blower Corp.
Bayley Blower Co.
Bishop & Babcock Sales Co.
Buffalo Forge Co.
Cooling & Air Conditioning Corp.
Garden City Fan Co.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
Maryland Air Conditioning Corp.
Midwest Mfg. Co.
National Air Filter Co.
John J. Nesbitt, Inc.
New York Blower Co.
Niagara Blower Co.
Parks-Cramer Co.
Reed Air Filter Co., Inc.
Skinner Bros. Mfg. Co.
Strandwitz & Scott, Inc.
B. F. Sturtevant Co.
Unit Heater & Cooler Co.
York Heating & Ventilating Corp.

AIR COMPRESSORS (*See Compressors, Air*)

AIR COOLING AND DEHUMIDIFYING APPARATUS
Aerofin Corp.
Air-Way Electric Appliance Corp.
American Blower Corp.
Bayley Blower Co.
Bishop & Babcock Sales Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Cooling & Air Conditioning Corp.
Ilg Electric Ventilating Co.
Maryland Air Conditioning Corp.
Herman Nelson Corp.
New York Blower Co.
Niagara Blower Co.
Parks-Cramer Co.
Peerless Unit Ventilation Co., Inc.
B. F. Sturtevant Co.
Thermal Units Co.
Whitlock Coil Pipe Co.
York Heating & Ventilating Corp.
York Ice Machinery Corp.

AIR ELIMINATORS
Cochrane Corp.
C. A. Dunham Co.
Hoffman Specialty Co.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
O-E Specialty Mfg. Co.
Reed Air Filter Co., Inc.
Sarco Co., Inc.
Sterling Engineering Co.

AIR FILTERS (*See Air Cleaning Equipment*)

AIR HEATING SYSTEMS (*See Heating Systems, Air*)

AIR MEASURING AND RECORDING INSTRUMENTS
Cochrane Corp.
De Bothezat Impeller Co., Inc.
Ellison Draft Gage Co.
E. Vernon Hill Co.
Reed Air Filter Co., Inc.
Webster Tallmadge & Co., Inc.

AIR MOISTENING APPARATUS (*See Humidifiers*)

AIR PURIFYING APPARATUS
United States Ozone Co.

AIR RECEIVERS (*See Receivers, Air*)

AIR VALVES (*See Valves, Air*)

AIR WASHERS (*See Air Cleaning Equipment*)

AMMONIA COILS (*See Coils, Ammonia*)

ASBESTOS PRODUCTS (*See Insulation*)

AUTOMATIC SHUTTERS (*See Shutters, Automatic*)

BENDS, Pipe
James B. Clow & Sons
Crane Co.
Grinnell Co., Inc.

BENDS, Return (*See Pipe, Return Bends*)

BLOWERS, Fan (*See Fans, Supply and Exhaust*)

BLOWERS, Forced Draft
American Blower Corp.
Bayley Blower Co.
Buffalo Forge Co.
Combustion Specialties Corp.
Garden City Fan Co.
B. F. Sturtevant Co.
L. J. Wing Mfg. Co.

BLOWERS, Heating and Ventilating
American Blower Corp.
Bayley Blower Co.
Bishop & Babcock Sales Co.
Buckeye Blower Co.
Buffalo Forge Co.
Combustion Specialties Corp.
Garden City Fan Co.
General Electric Co.
W. F. Hirschman Co., Inc.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
New York Blower Co.
Niagara Blower Co.
Skinner Bros. Mfg. Co., Inc.
B. F. Sturtevant Co.
Thermal Units Co.
Thermidaire Corp.
L. J. Wing Mfg. Co.

BLOWERS, Pressure
Bayley Blower Co.
Buffalo Forge Co.
Combustion Specialties Corp.
Garden City Fan Co.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
New York Blower Co.
B. F. Sturtevant Co.
L. J. Wing Mfg. Co.

BLOWERS, Turbine
American Blower Corp.
Bayley Blower Co.
Buffalo Forge Co.
Garden City Fan Co.
General Electric Co.
New York Blower Co.
B. F. Sturtevant Co.
L. J. Wing Mfg. Co.

BOILER COMPOUNDS (*See Compounds, Boiler*)

BOILER COVERING (*See Covering, Pipes and Surfaces*)

BOILER FEEDERS (*See Feeders, Boiler*)

BOILER FEED PUMPS (*See Pumps, Boiler Feed*)

BOILERS, Cast Iron
American Radiator Co.
Bryant Heater & Mfg. Co.
Burnham Boiler Corp.
Central Radiator Co.
James B. Clow & Sons
Molby Boiler Co., Inc.
L. J. Mueller Furnace Co.
National Radiator Corp.
Wm. H. Page Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Pittsburg Water Heater Co.
Richardson & Boynton Co.
Richmond Radiator Co.
Spencer Heater Co.
United States Radiator Corp.
Weil-McLain Co.

BOILERS, Combination, Gas, Coal, or Oil
American Radiator Co.
Brownell Co.
Monitor Boiler Co.
National Radiator Corp.
Wm. H. Page Boiler Co.
Richardson & Boynton Co.
Richmond Radiator Co.
Stanwood Corp.

BOILERS, Down Draft
Ames Iron Works
Brownell Co.
Erie City Iron Works

Catalog Data of Manufacturers listed can be located by referring to pages 885 to 888

Harrisburg Star Boiler Co.
Kewanee Boiler Co.
Oil City Boiler Works
Pacific Steel Boiler Corp.
Wm. H. Page Boiler Co.
Stanwood Corp.
Titusville Iron Works

BOILERS, Gas Fired

American Gas Products Corp.
Bryant Heater & Mfg. Co.
James B. Clow & Sons
L. J. Mueller Furnace Co.
Pittsburg Water Heater Co.
Richmond Radiator Co.

BOILERS, Heating

American Radiator Co.
Ames Iron Works
Bigelow Co.
Brownell Co.
Burnham Boiler Corp.
Central Radiator Co.
James B. Clow & Sons
Erie City Iron Works
Fitzgibbons Boiler Co., Inc.
Harrisburg Star Boiler Co.
Heggie-Simplex Boiler Co.
Kewanee Boiler Co.
Leader Boiler & Heater Co.
Molby Boiler Co., Inc.
Monitor Boiler Co.
L. J. Mueller Furnace Co.
Newport Boiler Co.
Oil City Boiler Works
Wm. H. Page Boiler Co.
Richardson & Boynton Co.
Richmond Radiator Co.
Stanwood Corp.
Titusville Iron Works
United States Radiator Corp.
Weil-McLain Co.
Wickes Boiler Co.

BOILERS, Magazine Feed

American Radiator Co.
Molby Boiler Co., Inc.
Newport Boiler Co.
Spencer Heater Co.
Weil-McLain Co.

BOILERS, Oil Burning

American Radiator Co.
Ames Iron Works
Bigelow Co.
Brownell Co.
Burnham Boiler Corp.
Erie City Iron Works
Fitzgibbons Boiler Co., Inc.
Harrisburg Star Boiler Co.
Heggie-Simplex Boiler Co.
Kewanee Boiler Co.
Leader Boiler & Heater Co.
Monitor Boiler Co.
L. J. Mueller Furnace Co.
Newport Boiler Co.
Oil City Boiler Works
Wm. H. Page Boiler Co.
Stanwood Corp.
Titusville Iron Works
Weil-McLain Co.

BOILERS, Steel

Ames Iron Works
Bigelow Co.
Brownell Co.
Coatesville Boiler Works
Edge Moor Iron Co.
Erie City Iron Works
Fitzgibbons Boiler Co., Inc.
Harrisburg Star Boiler Co.
Heggie-Simplex Boiler Co.
Kewanee Boiler Co.
Leader Boiler & Heater Co.
Oil City Boiler Works
Pacific Steel Boiler Corp.
Pierce, Butler & Pierce Mfg. Corp. (Ames Div.)
Stanwood Corp.
Titusville Iron Works
Wickes Boiler Co.

BREECHINGS AND CHIMNEYS

Ames Iron Works
Bigelow Co.
Brownell Co.
Burnham Boiler Corp.
Erie City Iron Works
Keasbey & Mattison Co.
Kewanee Boiler Co.
Oil City Boiler Works
Stanwood Corp.
Titusville Iron Works
Whitlock Coil Pipe Co.
Wickes Boiler Co.

BURNERS, Coal, Automatic (*See Stokers*)

BURNERS, Oil (*See Oil Burners*)

CALORIMETERS, Steam

Ellison Draft Gage Co.

CIRCULATORS, Hot Water Heating

Rochester Circulator Co.
Sterling Engineering Co.
H. A. Thrush & Co.

COILS, Ammonia

James B. Clow & Sons
Crane Co.
Whitlock Coil Pipe Co.
York Ice Machinery Corp.

COILS, Pipe, Copper

E. B. Badger & Sons Co.
James B. Clow & Sons
Rome-Turney Radiator Co.
Whitlock Coil Pipe Co.

COILS, Pipe, Iron

American Radiator Co.
Bayley Blower Co.
Crane Co.
Garden City Fan Co.

COILS, Tank

E. B. Badger & Sons Co.
Patterson-Kelley Co.
Whitlock Coil Pipe Co.

COLUMNS, Alarm, Water

Wright-Austin Co.

COMPOUNDS, Boiler

Richardson & Boynton Co.
United States Radiator Corp.
Vinco Co., Inc.

COMPOUNDS, Boiler and Radiator Sealing

Vinco Co., Inc.

COMPRESSORS, Air

American Steam Pump Co.
Garden City Fan Co.
General Electric Co.
Johnson Service Co.
Nash Engineering Co.
National Regulator Co.
Powers Regulator Co.
B. F. Sturtevant Co.

CONCRETE INSERTS (*See Inserts, Concrete*)

CONDENSERS

Alberger Heater Co.
American Steam Pump Co.
Cochrane Corp.
Davis Engineering Corp.
O. E. Frank Heater & Engineering Co., Inc.
Rome-Turney Radiator Co.
Schutte & Koerting Co.
Whitlock Coil Pipe Co.
York Ice Machinery Corp.

CONDUITS, Underground Pipe

American District Steam Co.
Johns-Manville Corp.
Ric-wiL Co.

CONTROLLERS AND CONTROL EQUIPMENT (*See Also Temperature Control*)

American Radiator Co.
D. & T. Mfg. Co.
General Electric Co.
Johnson Service Co.
Minneapolis-Honeywell Regulator Co.
National Regulator Co.
Powers Regulator Co.
Webster Tallmadge & Co., Inc.
Time-O-Stat Controls Co.
Westinghouse Electric & Mfg. Co.
Wright-Austin Co.

COOLING EQUIPMENT, Oil and Water (*See Also Air Cooling And Dehumidifying Apparatus*)

Bayley Blower Co.
Davis Engineering Corp.
O. E. Frank Heater & Engineering Co., Inc.
Patterson-Kelley Co.
Whitlock Coil Pipe Co.

COVERING, Ammonia Pipe

Crane Co.

COVERING, Pipes and Surfaces

American District Steam Co.
Armstrong Cork & Insulation Co.
Johns-Manville Corp.
Keasbey & Mattison Co.
Wm. H. Page Boiler Co.
Ric-wiL Co.

CUTTING AND WELDING APPARATUS (*See Welding And Cutting Apparatus*)

DAMPERS

Ames Iron Works
D. & T. Mfg. Co.
W. F. Hirschman Co., Inc.
L. J. Mueller Furnace Co.
National Regulator Co.
Niagara Blower Co.
Powers Regulator Co.
Thermidaire Corp.

DAMPER REGULATORS, Boiler and Furnace

American District Steam Co.
American Radiator Co.

Bishop & Babcock Sales Co.
Burnham Boiler Corp.
D. & T. Mfg. Co.
Julian D'Este Co.
C. A. Dunham Co.
Hoffman Specialty Co.
Kainer & Co.
Kieley & Mueller, Inc.
Minneapolis-Honeywell Regulator Co.
National Regulator Co.
Wm. H. Page Boiler Co.
Richardson & Boynton Co.
Sarco Co., Inc.
Trane Co.
Vapor Engineering Co.
Warren Webster & Co.

DEAERATORS

Cochrane Corp.

DIFFUSERS *(See Ventilators, Floor and Wall)*

DRAFT APPARATUS Mechanical

Buffalo Forge Co.
Combustion Specialties Corp.
Ilg Electric Ventilating Co.
Kieley & Mueller, Inc.
National Regulator Co.
B. F. Sturtevant Co.
L. J. Wing Mfg. Co.

DRYING EQUIPMENT

Air-Way Electric Appliance Corp.
American Blower Corp.
Bayley Blower Co.
Bishop & Babcock Sales Co.
Carrier Engineering Corp.
Circulair Heat, Inc.
Cooling & Air Conditioning Corp.
Garden City Fan Co.
W. F. Hirschman Co., Inc.
Johnson Fan & Blower Co.
Maryland Air Conditioning Corp.
New York Blower Co.
Niagara Blower Co.
Skinner Bros. Mfg. Co., Inc.
B. F. Sturtevant Co.
Thermal Units Co.
Trane Co.
Unit Heater & Cooler Co.

DRY KILNS *(See Kilns, Dry)*

DUST SEPARATORS *(See Air Cleaning Equipment)*

EXHAUST HEADS

W. F. Hirschman Co., Inc.
Illinois Engineering Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Skinner Bros. Mfg. Co., Inc.
B. F. Sturtevant Co.
Swartwout Co.
Wright-Austin Co.

EXPANSION JOINTS

Alberger Heater Co.
American District Steam Co.
American Radiator Co.
E. B. Badger & Sons Co.
James B. Clow & Sons
Crane Co.
Illinois Engineering Co.
Schutte & Koerting Co.
Warren Webster & Co.

FANS, Furnace

Buffalo Forge Co.
Combustion Specialties Corp.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
L. J. Mueller Furnace Co.
New York Blower Co.
Richardson & Boynton Co.
B. F. Sturtevant Co.
L. J. Wing Mfg. Co.

FANS, Supply and Exhaust

American Blower Corp.
Bayley Blower Co.
Bishop & Babcock Sales Co.
Buckeye Blower Co.
Buffalo Forge Co.
De Bothezat Impeller Co., Inc.
Garden City Fan Co.
General Electric Co.
W. F. Hirschman Co., Inc.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
New York Blower Co.
Niagara Blower Co.
Skinner Bros. Mfg. Co., Inc.
B. F. Sturtevant Co.
L. J. Wing Mfg. Co.
York Heating & Ventilating Corp.

FEEDERS, Boiler

American Steam Pump Co.
Goulds Pumps, Inc.
Grinnell Co., Inc.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
McDonnell & Miller
Mueller Steam Specialty Co.
Wm. H. Page Boiler Co.
Schutte & Koerting Co.

FEEDERS, Water

Decatur Pump Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
McDonnell & Miller
United States Radiator Corp.

FEED WATER HEATERS *(See Heaters, Feed Water)*

FEED WATER REGULATORS *(See Regulators, Feed Water)*

FILTERS, Air *(See Air Cleaning Equipment)*

FITTINGS, Pipe, Flanged

James B. Clow & Sons
Crane Co.
Grinnell Co., Inc.
Stockham Pipe & Fittings Co.
York Ice Machinery Corp.

FITTINGS, Pipe, Screwed

James B. Clow & Sons
Crane Co.
D. & T. Mfg. Co.
Grinnell Co., Inc.
Stockham Pipe & Fittings Co.
York Ice Machinery Corp.

FURNACE HEATING SYSTEMS *(See Heating Systems, Furnace)*

FURNACES, Electric

General Electric Co.
Westinghouse Electric & Mfg. Co.

FURNACES, Warm Air

American Gas Products Corp.
Bryant Heater & Mfg. Co.
James B. Clow & Sons
Langenberg Mfg. Co.
L. J. Mueller Furnace Co.
Richardson & Boynton Co.

GAS HEATERS *(See Heaters, Gas)*

GASKETS, Asbestos

Crane Co.
Jenkins Bros.
Keasbey & Mattison Co.

GASKETS, Metallic

James B. Clow & Sons

GASKETS, Rubber

James B. Clow & Sons

GAUGE BOARDS

Consolidated Ashcroft Hancock Co., Inc.
J. E. Lonergan Co.
Jas. P. Marsh & Co.

GAUGE GLASSES

Crane Co.
Jenkins Bros.
J. E. Lonergan Co.

GAUGES, Altitude

American Radiator Co.
Crane Co.
J. E. Lonergan Co.
Jas. P. Marsh & Co.
New York Air Valve Corp.
Wm. H. Page Boiler Co.
Richardson & Boynton Co.

GAUGES, Ammonia

Crane Co.
J. E. Lonergan Co.
Jas. P. Marsh & Co.
New York Air Valve Corp.

GAUGES, Draft

Consolidated Ashcroft Hancock Co., Inc.
Ellison Draft Gage Co.
E. Vernon Hill Co.
National Air Filter Co.

GAUGES, Hot Water

American Radiator Co.
D. & T. Mfg. Co.
J. E. Lonergan Co.
Jas. P. Marsh & Co.
New York Air Valve Corp.
Wm. H. Page Boiler Co.
Richardson & Boynton Co.
United States Radiator Corp.

GAUGES, Pressure

American Radiator Co.
Consolidated Ashcroft Hancock Co., Inc.
Crane Co.
C. A. Dunham Co.
Kainer & Co.
J. E. Lonergan Co.
Jas. P. Marsh & Co.
O-E Specialty Mfg. Co.
Wm. H. Page Boiler Co.
Petroleum Heat & Power Co.
Trane Co.
United States Radiator Corp.

GAUGES, Steam

American Radiator Co.
Crane Co.
J. E. Lonergan Co.
Jas. P. Marsh & Co.
New York Air Valve Corp.
Wm. H. Page Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Richardson & Boynton Co.
Webster Tallmadge & Co., Inc.
Trane Co.
United States Radiator Corp.

GAUGES, Vacuum

American District Steam Co.
American Radiator Co.
Consolidated Ashcroft Hancock Co., Inc.
Crane Co.
C. A. Dunham Co.
Grinnell Co., Inc.
Hoffman Specialty Co.
Illinois Engineering Co.
J. E. Lonergan Co.
Jas. P. Marsh & Co.
New York Air Valve Corp.
O-E Specialty Mfg. Co.
Wm. H. Page Boiler Co.
Richardson & Boynton Co.
Webster Tallmadge & Co., Inc.
Trane Co.
United States Radiator Corp.

GAUGES, Vapor

American District Steam Co.
American Radiator Co.
C. A. Dunham Co.
Grinnell Co., Inc.
Hoffman Specialty Co.
Illinois Engineering Co.
J. E. Lonergan Co.
Jas. P. Marsh & Co.
New York Air Valve Corp.
Wm. H. Page Boiler Co.
Richardson & Boynton Co.
Webster Tallmadge & Co., Inc.
Trane Co.
United States Radiator Corp.

GAUGES, Water

American Radiator Co.
Crane Co.
J. E. Lonergan Co.
Jas. P. Marsh & Co.
New York Air Valve Corp.
Wm. H. Page Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Richardson & Boynton Co.
United States Radiator Corp.
Wright-Austin Co.

GOVERNORS, Pump

G. M. Davis Regulator Co.
Julian D'Este Co.
C. A. Dunham Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co.
Petroleum Heat & Power Co.
Swartwout Co.
Wright-Austin Co.

GRATES FOR BOILERS AND FURNACES

Ames Iron Works
Brownell Co.
Erie City Iron Works
Fitzgibbons Boiler Co., Inc.
Kewanee Boiler Co.
Oil City Boiler Works
Pierce, Butler & Pierce Mfg. Corp.
Richardson & Boynton Co.
Titusville Iron Works
Wickes Boiler Co.

GRILLES, REGISTERS AND ORNAMENTAL METAL WORK

Auer Register Co.
Circulair Heat, Inc.
Knowles Mushroom Ventilator Co.
Langenberg Mfg. Co.
L. J. Mueller Furnace Co.
Schleicher, Inc.
Tuttle & Bailey Mfg. Co.

HANGERS, Pipe

James B. Clow & Sons
Crane Co.
Grinnell Co., Inc.

HANGERS, Radiator

American Radiator Co.
Burnham Boiler Corp.
Circulair Heat, Inc.
James B. Clow & Sons
Grinnell Co., Inc.
Healy-Ruff Co.
Kewanee Boiler Co.
McAlear Mfg. Co.
Wm. H. Page Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Sterling Engineering Co.
United States Radiator Corp.

HEAT CABINETS (*See Heaters, Cabinet*)

HEATERS, Air

Aerofin Corp.
Air-Way Electric Appliance Corp.
American Blower Corp.
American Radiator Co.
Bayley Blower Co.
Buffalo Forge Co.
Carrier-Lyle Corp.
Circulair Heat, Inc.
Garden City Fan Co.
Hoffman Specialty Co.
McQuay Radiator Corp.
John J. Nesbitt, Inc.
New York Blower Co.
Peerless Unit Ventilation Co., Inc.
Rome Brass Radiator Corp.
Rome-Turney Radiator Co.
Schutte & Koerting Co.
Skinner Bros. Mfg. Co., Inc.
B. F. Sturtevant Co.
Texo Heater & Mfg. Corp.
Thermal Units Co.
Trane Co.

HEATERS, Automatic Hot Water

American Radiator Co.
Bell & Gossett Co.
Crane Co.
Electrol Incorporated
Pacific Steel Boiler Corp.
Pittsburg Water Heater Co.

HEATERS, Blast

Aerofin Corp.
Air-Way Electric Appliance Corp.
American Blower Corp.
American Radiator Co.
Circulair Heat, Inc.
Garden City Fan Co.
New York Blower Co.
Peerless Unit Ventilation Co., Inc.
Rome Brass Radiator Co.
Rome-Turney Radiator Co.
Skinner Bros. Mfg. Co., Inc.
B. F. Sturtevant Co.
Trane Co.

HEATERS, Cabinet

Air-Way Electric Appliance Corp.
Circulair Heat, Inc.
McQuay Radiator Corp.
L. J. Mueller Furnace Co.
Herman Nelson Corp.
Schleicher, Inc.
B. F. Sturtevant Co.
Texo Heater & Mfg. Corp.
Thermal Units Co.
Trane Co.

HEATERS, Electric

Air-Way Electric Appliance Corp.
General Electric Co.
Hoffman Specialty Co.
Schleicher, Inc.
Rome Brass Radiator Corp.
Trane Co.
Westinghouse Electric & Mfg. Co.

HEATERS, Feed Water

Alberger Heater Co.
Brownell Co.
Cochrane Corp.
O. E. Frank Heater & Engrg. Co., Inc.
Patterson-Kelley Co.
Rome Brass Radiator Co.
Schutte & Koerting Co.
Stanwood Corp.
Wickes Boiler Co.
Swartwout Co.

HEATERS, Gas

American Gas Products Corp.
American Radiator Co.
Bryant Heater & Mfg. Co.
Carrier-Lyle Corp.
James B. Clow & Sons
L. J. Mueller Furnace Co.
Niagara Blower Co.
Pittsburg Water Heater Co.
Richmond Radiator Co.
Texo Heater & Mfg. Corp.

HEATERS, Hot Water Service

Alberger Heater Co.
American Radiator Co.
Bell & Gossett Co.
Brownell Co.
Cochrane Corp.
Davis Engineering Corp.
Excelso Products Corp.
O. E. Frank Heater & Engrg. Co., Inc.
Kewanee Boiler Co.
Monitor Boiler Co.
L. J. Mueller Furnace Co.
Neptune Meter Co.
Wm. H. Page Boiler Co.
Patterson-Kelley Co.
Pierce, Butler & Pierce Mfg. Corp.
Richardson & Boynton Co.
Rome Brass Radiator Co.
H. A. Thrush & Co.
Weil-McLain Co.
Whitlock Coil Pipe Co.

HEATERS, Indirect

American Radiator Co.
Bell & Gossett Co.
Davis Engineering Corp.

Catalog Data of Manufacturers listed can be located by referring to pages 885 to 888

Excelso Products Corp.
Patterson-Kelley Co.
Pittsburg Water Heater Co.
Richardson & Boynton Co.
Rome Brass Radiator Co.
United States Radiator Corp.

HEATERS, Storage

Alberger Heater Co.
American Radiator Co.
Cochrane Corp.
Davis Engineering Corp.
O. E. Frank Heater & Engrg. Co., Inc.
Patterson-Kelley Co.
Pittsburg Water Heater Co.
Richardson & Boynton Co.
Rome Brass Radiator Co.
Whitlock Coil Pipe Co.

HEATERS, Tank

American District Steam Co.
American Radiator Co.
Burnham Boiler Corp.
Excelso Products Corp.
Kewanee Boiler Co.
L. J. Mueller Furnace Co.
Wm. H. Page Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Richardson & Boynton Co.
Schutte & Koerting Co.
Stanwood Corp.
United States Radiator Corp.
Weil-McLain Co.

HEATERS, Unit

Air-Way Electric Appliance Corp.
American Blower Corp.
Bayley Blower Co.
Bishop & Babcock Sales Co.
Buckeye Blower Co.
Buffalo Forge Co.
De Bothezat Impeller Co., Inc.
Dixie Blower Co.
Garden City Fan Co.
Grinnell Co., Inc.
Hoffman Specialty Co.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
McQuay Radiator Corp.
Herman Nelson Corp.
John J. Nesbitt, Inc.
New York Blower Co.
Niagara Blower Co.
Peerless Unit Ventilation Co., Inc.
Richardson & Boynton Co.
Skinner Bros. Mfg. Co., Inc.
B. F. Sturtevant Co.
Texo Heater & Mfg. Corp.
Thermal Units Co.
Thermidaire Corp.
Trane Co.
United States Radiator Corp.
Unit Heater & Cooler Co.
L. J. Wing Mfg. Co.
York Heating & Ventilating Corp.

HEATING SYSTEMS, Air

American Blower Corp.
Carrier-Lyle Corp.
Circulair Heat, Inc.
Garden City Fan Co.
Ilg Electric Ventilating Co.
Langenberg Mfg. Co.
New York Blower Co.
Peerless Unit Ventilation Co., Inc.
Richardson & Boynton Co.
Skinner Bros. Mfg. Co., Inc.
B. F. Sturtevant Co.
Thermal Units Co.
York Heating & Ventilating Corp.

HEATING SYSTEMS, Furnace

Burnham Boiler Corp.
James B. Clow & Sons
Langenberg Mfg. Co.
L. J. Mueller Furnace Co.
Richardson & Boynton Co.
Skinner Bros. Mfg. Co., Inc.

HEATING SYSTEMS, Hot Water

Barnes & Jones
Burnham Boiler Corp.
Circulair Heat, Inc.
James B. Clow & Sons
D. & T. Mfg. Co.
Mueller Co.
L. J. Mueller Furnace Co.
Neptune Meter Co.
Wm. H. Page Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Richardson & Boynton Co.
Thermal Units Co.
H. A. Thrush & Co.
Titusville Iron Works
United States Radiator Corp.

HEATING SYSTEMS, Steam

American District Steam Co.
Barnes & Jones
Bishop & Babcock Sales Co.
Burnham Boiler Corp.
Circulair Heat, Inc.
James B. Clow & Sons
C. A. Dunham Co.
Wm. S. Haines & Co.
Hoffman Specialty Co.
Ilg Electric Ventilating Co.
Illinois Engineering Co.
Kelly Brass Works
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
L. J. Mueller Furnace Co.
Wm. H. Page Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Richardson & Boynton Co.
Thermal Units Co.
United States Radiator Corp.
Warren Webster & Co.

HEATING SYSTEMS, Vacuum

Barnes & Jones
Bishop & Babcock Sales Co.
Burnham Boiler Corp.
Circulair Heat, Inc.
C. A. Dunham Co.
Wm. S. Haines & Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Kelly Brass Works
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
L. J. Mueller Furnace Co.
Newport Boiler Co.
O-E Specialty Mfg. Co.
Wm. H. Page Boiler Co.
Sarco Co., Inc.
Skidmore Corp.
Sterling Engineering Co.
Webster Tallmadge & Co., Inc.
Thermal Units Co.
Trane Co.
United States Radiator Corp.
Warren Webster & Co.

HEATING SYSTEMS, Vapor

American District Steam Co.
Barnes & Jones
Bishop & Babcock Sales Co.
Burnham Boiler Corp.
Circulair Heat, Inc.
James B. Clow & Sons
C. A. Dunham Co.
Wm. S. Haines & Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
L. J. Mueller Furnace Co.
Newport Boiler Co.
O-E Specialty Mfg. Co.
Wm. H. Page Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Sarco Co., Inc.
Sterling Engineering Co.
Webster Tallmadge & Co., Inc.
Thermal Units Co.
Trane Co.
United States Radiator Corp.
Unit Heater & Cooler Co.
Vapor Engineering Co.
Warren Webster & Co.

HEAT SURFACE, Fan System

Aerofin Corp.
Air-Way Electric Appliance Corp.
American Radiator Co.
Bayley Blower Co.
Hoffman Specialty Co., Inc.
McCord Radiator & Mfg. Co.
Rome-Turney Radiator Co.
Schutte & Koerting Co.
Thermal Units Co.
Winchester Repeating Arms Co.
Wolverine Tube Co.
York Heating & Ventilating Corp.

HOT WATER HEATING SYSTEMS (*See Heating Systems, Hot Water*)

HUMIDIFIERS

American Blower Corp.
Bahnson Co.
Bayley Blower Co.
Bishop & Babcock Sales Co.
Buffalo Forge Co.
Carrier Engineering Corp.
Cooling & Air Conditioning Corp.
Grinnell Co., Inc.
Ilg Electric Ventilating Co.
Johnson Service Co.
Maryland Air Conditioning Corp
Midwest Mfg. Co.
L. J. Mueller Furnace Co.
National Regulator Co.
New York Blower Co.
Niagara Blower Co.
Parks-Cramer Co.
Peerless Unit Ventilation Co., Inc.
Powers Regulator Co.
Richardson & Boynton Co.
Strandwitz & Scott, Inc.
Thermal Units Co.
York Heating & Ventilating Corp.
York Ice Machinery Corp.

HUMIDIFIERS, Unit

Buffalo Forge Co.
Maryland Air Conditioning Corp.
Niagara Blower Co.
Thermal Units Co.
York Heating & Ventilating Corp.

HUMIDITY CONTROL

American Blower Corp.
Bahnson Co.
Bishop & Babcock Sales Co.
Carrier Engineering Corp.
Consolidated Ashcroft Hancock Co., Inc.
Cooling & Air Conditioning Corp.

Catalog Data of Manufacturers listed can be located by referring to pages 885 to 888

Grinnell Co., Inc.
Johnson Service Co.
National Regulator Co.
New York Blower Co.
Niagara Blower Co.
Parks-Cramer Co.
Powers Regulator Co.
York Heating & Ventilating Corp.
York Ice Machinery Corp.

INCINERATORS
Kewanee Boiler Co.
L. J. Mueller Furnace Co.

INSERTS, Concrete
Grinnell Co., Inc.
Healy-Ruff Co.

INSTRUMENTS, Indicating and Recording
General Electric Co.
Jas. P. Marsh & Co.
Westinghouse Electric & Mfg. Co.

INSULATION, Building
Armstrong Cork & Insulation Co.
Samuel Cabot, Inc.
Celotex Co.
Chicago Mill & Lumber Co.
Flax-li-num Insulating Co.
Insulite Co.
International Fibre Board, Ltd.
Johns-Manville Corp.
MacAndrews & Forbes Co.
Masonite Corp.
Pennrich & Co.
Sprayo-Flake Co.
Stewart Inso Board Co.
Thermo-Proof Insulation Co.
Wood Conversion Co.

INSULATION, Pipes and Surfaces (*See Covering, Pipes and Surfaces*)

INSULATION, Sound Deadening
Armstrong Cork & Insulation Co.
Samuel Cabot, Inc.
Celotex Co.
Chicago Mill & Lumber Co.
Flax-li-num Insulating Co.
Insulite Co.
International Fibre Board, Ltd.
Johns-Manville Corp.
MacAndrews & Forbes Co.
Masonite Corp.
Pennrich & Co.
Sprayo-Flake Co.
Stewart Inso Board Co.
Thermo-Proof Insulation Co.
Wood Conversion Co.

KILNS, Dry
Bayley Blower Co.
New York Blower Co.
B. F. Sturtevant Co.
Thermal Units Co.

LOUVRES
Auer Register Co.
Buckeye Blower Co.
W. F. Hirschman Co., Inc.
National Regulator Co.
B. F. Sturtevant Co.
Swartwout Co.

MECHANICAL DRAFT APPARATUS (*See Draft Apparatus, Mechanical*)

METERS, Air
Builders Iron Foundry
Cochrane Corp.

METERS, Condensation
American District Steam Co.
Builders Iron Foundry

METERS, Feed Water
Builders Iron Foundry
Cochrane Corp.

METERS, Flow
American District Steam Co.
Builders Iron Foundry
Cochrane Corp.
Petroleum Heat & Power Co.

METERS, Steam
American District Steam Co.
Builders Iron Foundry
Cochrane Corp.

METERS, Water
Builders Iron Foundry
Cochrane Corp.

MOTORS, Electric
General Electric Co.
Minneapolis-Honeywell Regulator Co.
B. F. Sturtevant Co.
Westinghouse Electric & Mfg. Co.

NOZZLES, Spray (*See Spray Nozzles*)

OIL BURNER EQUIPMENT
Electrol Incorporated
Hardinge Brothers, Inc.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Minneapolis-Honeywell Regulator Co.
Newport Boiler Co.
Petroleum Heat & Power Co.
Schutte & Koerting Co.

OIL BURNERS
Automatic Burner Corp.
Electrol Incorporated
Hardinge Brothers, Inc.
May Oil Burner Corp.
Petroleum Heat & Power Co.
Williams Oil-O-Matic Heating Corp.
Winslow Boiler & Engrg. Co.

OZONE APPARATUS
Langenberg Mfg. Co.
United States Ozone Co.

PACKING
Jenkins Bros.
Ric-wiL Co.

PANELS, Access
Higgin Mfg. Co.
Schleicher, Inc.

PIPE BENDING
James B. Clow & Sons
Crane Co.
Grinnell Co., Inc.
York Ice Machinery Corp.

PIPE, Brass
James B. Clow & Sons
Crane Co.

PIPE, Cast Iron
American Radiator Co.
James B. Clow & Sons
Crane Co.

PIPE COILS (*See Coils, Pipe*)

PIPE CONDUITS (*See Conduits, Underground Pipe*)

PIPE COVERING (*See Covering, Pipes and Surfaces*)

PIPE FITTINGS (*See Fittings, Pipe*)

PIPE HANGERS (*See Hangers, Pipe*)

PIPE, Return Bends
Stockham Pipe & Fitting Co.
York Ice Machinery Corp.

PIPE SLEEVES, Adjustable
Knowles Pipe Sleeve Co.

PIPE, Steel
James B. Clow & Sons
Crane Co.

PIPE, Wrought Iron
James B. Clow & Sons
Crane Co.
Ric-wiL Co.

PITOT TUBES (*See Air Measuring and Recording Instruments*)

PRESSURE REDUCING VALVES (*See Regulators, Pressure*)

PSYCHROMETERS (*See Air Measuring and Recording Instruments*)

PUBLICATIONS
Heating & Ventilating

PUMP GOVERNORS
G. M. Davis Regulator Co.
Julian D'Este Co.
C. A. Dunham Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Mueller Steam Specialty Co.

PUMPS, Air and Gas
American Steam Pump Co.
Chicago Pump Co.
Decatur Pump Co.
Economy Pumping Machinery Co.
Nash Engineering Co.

PUMPS, Ammonia
American Steam Pump Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
York Ice Machinery Corp.

Catalog Data of Manufacturers listed can be located by referring to pages 885 to 888

PUMPS, Boiler Feed
American Steam Pump Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
Decatur Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
Wm. H. Page Boiler Co.
Skidmore Corp.
Sterling Engineering Co.
Trane Co.

PUMPS, Brine
American Steam Pump Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
Decatur Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
Trane Co.
York Ice Machinery Corp.

PUMPS, Centrifugal
American Steam Pump Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
C. A. Dunham Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
Trane Co.

PUMPS, Circulating
American Steam Pump Co.
Chicago Pump Co.
Decatur Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
Rochester Circulator Co.
Sterling Engineering Co.
H. A. Thrush & Co.
Trane Co.

PUMPS, Condensation
American Steam Pump Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
Decatur Pump Co.
C. A. Dunham Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Hoffman Specialty Co.
Nash Engineering Co.
Skidmore Corp.
Sterling Engineering Co.
Trane Co.

PUMPS, Oil
American Steam Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Petroleum Heat & Power Co.
Schutte & Koerting Co.

PUMPS, Steam
American Steam Pump Co.
Buffalo Steam Pump Co.
Economy Pumping Machinery Co.
Petroleum Heat & Power Co.

PUMPS, Sump
American Steam Pump Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Nash Engineering Co.
Trane Co.

PUMPS, Turbine
American Steam Pump Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Petroleum Heat & Power Co.

PUMPS, Vacuum
American Steam Pump Co.
Buffalo Steam Pump Co.
Chicago Pump Co.
C. A. Dunham Co.
Economy Pumping Machinery Co.
Goulds Pumps, Inc.
Hoffman Specialty Co.
Nash Engineering Co.
Schutte & Koerting Co.
Skidmore Corp.

RADIATION, Aluminum, Brass, Copper, Steel, Etc., Plain and Extended Surface
Aerofin Corp.
Air-Way Electric Appliance Corp.
American Radiator Co.
Circulair Heat, Inc.
McCord Radiator & Mfg. Co.
McQuay Radiator Corp.
Herman Nelson Corp.
John J. Nesbitt, Inc.
Richmond Radiator Co.
Rome Brass Radiator Co.
Rome-Turney Radiator Co.
Schutte & Koerting Co.
B. F. Sturtevant Co.
Thermal Units Co.
Thermidaire Corp.
Trane Co.
Unit Heater & Cooler Co.
Winchester Repeating Arms Co.
Wolverine Tube Co.
York Heating & Ventilating Corp.

RADIATION, Cast Iron
American Radiator Co.
Bayley Blower Co.
Burnham Boiler Corp.
Central Radiator Co.
James B. Clow & Sons
Kewanee Boiler Co.
National Radiator Corp.
Wm. H. Page Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Richardson & Boynton Co.
Richmond Radiator Co.
United States Radiator Corp.
Weil-McLain Co.

RADIATOR AIR VALVES (*See Valves, Air*)

RADIATOR ENCLOSURES AND SHIELDS
American Radiator Co.
Auer Register Co.
Circulair Heat, Inc.
McQuay Radiator Corp.
Schleicher, Inc.
Tuttle & Bailey Mfg. Co.
United States Radiator Corp.

RADIATOR HANGERS (*See Hangers, Radiator*)

RADIATORS, Cabinet and Concealed
Air-Way Electric Appliance Corp.
Circulair Heat, Inc.
McQuay Radiator Corp.
Herman Nelson Corp.
John J. Nesbitt, Inc.
Rome Brass Radiator Co.
Rome-Turney Radiator Co.
Thermal Units Co.
Thermidaire Corp.
Trane Co.

RECEIVERS, Air
Illinois Engineering Co.
Kewanee Boiler Co.
Vapor Engineering Co.

RECEIVERS, Condensation
American District Steam Co.
American Steam Pump Co.
Decatur Pump Co.
Julian D'Este Co.
C. A. Dunham Co.
Goulds Pumps, Inc.
Illinois Engineering Co.
Klipfel Mfg. Co.
Vapor Engineering Co.

REFRIGERATING MACHINERY
Carrier Engineering Corp.
Cooling & Air Conditioning Corp.
Rome-Turney Radiator Co.
B. F. Sturtevant Co.
Williams Oil-O-Matic Heating Corp.
York Ice Machinery Corp.

REGISTERS (*See Grilles, Registers, Etc.*)

REGULATORS, Damper
American District Steam Co.
American Radiator Co.
Bishop & Babcock Sales Co.
Burnham Boiler Corp.
D. & T. Mfg. Co.
Julian D'Este Co.
C. A. Dunham Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Jenkins Bros.
Kainer & Co.
Kieley & Mueller, Inc.
Minneapolis-Honeywell Regulator Co.
National Regulator Co.
Wm. H. Page Boiler Co.
Petroleum Heat & Power Co.
Powers Regulator Co.
Richardson & Boynton Co.
Sarco Co., Inc.
Time-O-Stat Controls Co.
Trane Co.
Vapor Engineering Co.

REGULATORS, Feed Water
Consolidated Ashcroft Hancock Co., Inc.
G. M. Davis Regulator Co.
Julian D'Este Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
McDonnell & Miller
Minneapolis-Honeywell Regulator Co.
Swartwout Co.
Wright-Austin Co.

REGULATORS, Humidity (*See Humidity Control*)

REGULATORS, Pressure

American Radiator Co.
Bishop & Babcock Sales Co.
Consolidated Ashcroft Hancock Co., Inc.
Crane Co.
G. M. Davis Regulator Co.
Julian D'Este Co.
C. A. Dunham Co.
Illinois Engineering Co.
Kainer & Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Minneapolis-Honeywell Regulator Co.
Mueller Co.
Mueller Steam Specialty Co.
O-E Specialty Mfg. Co.
Petroleum Heat & Power Co.
Powers Regulator Co.
Richardson & Boynton Co.
Sarco Co., Inc.
Schutte & Koerting Co.
H. A. Thrush & Co.
Time-O-Stat Controls Co.
Trane Co.

REGULATORS, Temperature (*See Temperature Control*)

RELIEF VALVES (*See Valves, Relief*)

SAFETY VALVES (*See Valves, Safety*)

SEPARATORS, Dust (*See Air Cleaning Equipment*)

SEPARATORS, Oil

Cochrane Corp.
Crane Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Patterson-Kelley Co.
Reed Air Filter Co., Inc.
Schutte & Koerting Co.
Swartwout Co.
Warren Webster & Co.
Wright-Austin Co.

SEPARATORS, Steam

American District Steam Co.
Cochrane Corp.
Crane Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Patterson-Kelley Co.
Swartwout Co.
Warren Webster & Co.
Wright-Austin Co.

SHUTTERS, Automatic

American Blower Corp.
Bishop & Babcock Sales Co.
Garden City Fan Co.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
Minneapolis-Honeywell Regulator Co.
National Regulator Co.
L. J. Wing Mfg. Co.

SOFTENERS, Water

Cochrane Corp.

SPRAY NOZZLES

American Blower Corp.
Buffalo Forge Co.
James B. Clow & Sons
New York Blower Co.
Schutte & Koerting Co.
B. F. Sturtevant Co.

STEAM HEATING SYSTEMS (*See Heating Systems, Steam*)

STOKERS, Mechanical

Brownell Co.
Combustion Specialties Corp.
Detroit Stoker Co.
Iron Fireman Mfg. Co.
Newport Boiler Co.
Westinghouse Electric & Mfg. Co.
Whiting Corp. (Harrington Div.)

STRAINERS, Oil

G. M. Davis Regulator Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
McDonnell & Miller
Mueller Co.
Mueller Steam Specialty Co.
Petroleum Heat & Power Co.
Sarco Co., Inc.
Schutte & Koerting Co.

STRAINERS, Steam

G. M. Davis Regulator Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
McDonnell & Miller
Mueller Co.
Mueller Steam Specialty Co.
Sarco Co., Inc.
Schutte & Koerting Co.

STRAINERS, Water

American District Steam Co.
G. M. Davis Regulator Co.
Illinois Engineering Co.
Kainer & Co.
Kieley & Mueller, Inc.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
McDonnell & Miller
Mueller Co.
Mueller Steam Specialty Co.
Sarco Co., Inc.
Schutte & Koerting Co.

TANK COILS (*See Coils, Tank*)

TANK COVERING (*See Covering, Pipes and Surfaces*)

TANK HEATERS (*See Heaters, Tank*)

TANKS, Blow-off

Ames Iron Works
Bigelow Co.
Coatesville Boiler Works
Economy Pumping Machinery Co.
Stanwood Corp.
Titusville Iron Works
Wickes Boiler Co.

TANKS, Storage

American Radiator Co.
Ames Iron Works
E. B. Badger & Sons Co.
Bigelow Co.
Brownell Co.
Burnham Boiler Corp.
Decatur Pump Co.
Erie City Iron Works
Kewanee Boiler Co.
Patterson-Kelley Co.
Stanwood Corp.
Titusville Iron Works
United States Radiator Corp.
Whitlock Coil Pipe Co.
Wickes Boiler Co.

TEMPERATURE CONTROL (*See Also Controllers*)

American Gas Products Corp.
American Radiator Co.
Bishop & Babcock Sales Co.
Consolidated Ashcroft Hancock Co., Inc.
D. & T. Mfg. Co.
Julian D'Este Co.
Direct Control Valve Co.
C. A. Dunham Co.
Illinois Engineering Co.
Johnson Service Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Langenberg Mfg. Co.
Jas. P. Marsh & Co.
Minneapolis-Honeywell Regulator Co.
Mueller Co.
National Regulator Co.
O-E Specialty Mfg. Co.
Petroleum Heat & Power Co.
Powers Regulator Co.
Sarco Co., Inc.
Sterling Engineering Co.
Webster Tallmadge & Co., Inc.
H. A. Thrush & Co.
Time-O-Stat Controls Co.
United States Radiator Corp.
Warren Webster & Co.

THERMOMETERS, Indicating and Recording

American Radiator Co.
Consolidated Ashcroft Hancock Co., Inc.
E. Vernon Hill Co.
Jas. P. Marsh & Co.
New York Air Valve Corp.
Palmer Co.
Petroleum Heat & Power Co.
Powers Regulator Co.
Richardson & Boynton Co.
United States Radiator Corp.

THERMOSTATS

American Gas Products Corp.
American Radiator Co.
Bishop & Babcock Sales Co.
Consolidated Ashcroft Hancock Co., Inc.
Julian D'Este Co.
Direct Control Valve Co.
Johnson Service Co.
Klipfel Mfg. Co.
Jas. P. Marsh & Co.
Minneapolis-Honeywell Regulator Co.
National Regulator Co.
Petroleum Heat & Power Co.
Powers Regulator Co.
Sarco Co., Inc.
H. A. Thrush & Co.
Time-O-Stat Controls Co.
United States Radiator Corp.

TRAPS, Bucket

Bishop & Babcock Sales Co.
Cochrane Corp.
Julian D'Este Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Mueller Steam Specialty Co.
Swartwout Co.
Wright-Austin Co.

TRAPS, Float

American District Steam Co.
Barnes & Jones
Cochrane Corp.
Crane Co.
G. M. Davis Regulator Co.
Julian D'Este Co.
C. A. Dunham Co.
Grinnell Co., Inc.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Mueller Steam Specialty Co.
Sarco Co., Inc.
Sterling Engineering Co.
Swartwout Co.
Warren Webster & Co.
Wright-Austin Co.

TRAPS, Radiator

American District Steam Co.
Barnes & Jones
Bishop & Babcock Sales Co.
C. A. Dunham Co.
Grinnell Co., Inc.
Wm. S. Haines & Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
Sarco Co., Inc.
Sterling Engineering Co.
United States Radiator Corp.
Vapor Engineering Co.
Warren Webster & Co.

TRAPS, Return

American Blower Corp.
American District Steam Co.
Barnes & Jones
Bishop & Babcock Sales Co.
Cochrane Corp.
Crane Co.
Julian D'Este Co.
C. A. Dunham Co.
Grinnell Co., Inc.
Wm. S. Haines & Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
O-E Specialty Mfg. Co.
Sarco Co., Inc.
Sterling Engineering Co.
Swartwout Co.
Trane Co.
United States Radiator Corp.
Vapor Engineering Co.
Warren Webster & Co.

TRAPS, Steam

American Blower Corp.
American District Steam Co.
Barnes & Jones
Bishop & Babcock Sales Co.
James B. Clow & Sons
Cochrane Corp.
Consolidated Ashcroft Hancock Co., Inc.
Crane Co.
Davis Engineering Corp.
G. M. Davis Regulator Co.
Julian D'Este Co.
C. A. Dunham Co.
Grinnell Co., Inc.
Wm. S. Haines & Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
O-E Specialty Mfg. Co.
Powers Regulator Co.
Sarco Co., Inc.
Sterling Engineering Co.
Swartwout Co.
United States Radiator Corp.
Warren Webster & Co.
Wright-Austin Co.

TRAPS, Vacuum

American Blower Corp.
American District Steam Co.
Barnes & Jones
Bishop & Babcock Sales Co.
Crane Co.
G. M. Davis Regulator Co.
C. A. Dunham Co.
Grinnell Co., Inc.
Wm. S. Haines & Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
O-E Specialty Mfg. Co.
Pierce, Butler & Pierce Mfg. Corp.
Sarco Co., Inc.
Schutte & Koerting Co.
Sterling Engineering Co.
Swartwout Co.
Time-O-Stat Controls Co.
Trane Co.
United States Radiator Corp.
Warren Webster & Co.

TUBING, Copper and Brass

James B. Clow & Sons
McCord Radiator & Mfg. Co.
Schutte & Koerting Co.
Wolverine Tube Co.

TURBINE BLOWERS (*See Blowers, Turbine*)

TURBINES

General Electric Co.
B. F. Sturtevant Co.
Westinghouse Electric & Mfg. Co.
L. J. Wing Mfg. Co.

UNDERGROUND PIPE CONDUITS (*See Conduits Underground Pipe*)

UNIT HEATERS (*See Heaters, Unit*)

UNIT VENTILATORS (*See Ventilators, Unit*)

UNITS, Air Conditioning

Maryland Air Conditioning Corp.
L. J. Mueller Furnace Co.
B. F. Sturtevant Co.
York Heating & Ventilating Corp.

VACUUM HEATING SYSTEMS (*See Heating Systems, Vacuum*)

VALVES, Air

American District Steam Co.
American Radiator Co.
Crane Co.
C. A. Dunham Co.
Hoffman Specialty Co.
Jenkins Bros.
Kelly Brass Works
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Monash-Younker Co., Inc.
New York Air Valve Corp.
O-E Specialty Mfg. Co.
Wm. H. Page Boiler Co.
Richardson & Boynton Co.
W. A. Russell & Co.
Sterling Engineering Co.
United States Radiator Corp.

VALVES, Angle, Globe and Cross

American Radiator Co.
James B. Clow & Sons
Consolidated Ashcroft Hancock Co., Inc.
Crane Co.
Fairbanks Co.
Grinnell Co., Inc.
Illinois Engineering Co.
Jenkins Bros.
Marsh Valve Co.
O-E Specialty Mfg. Co.
Wm. H. Page Boiler Co.
Schutte & Koerting Co.
United States Radiator Corp.

VALVES, Anti-Siphon

James B. Clow & Sons
Petroleum Heat & Power Co.

VALVES, Back Pressure

Cochrane Corp.
Crane Co.
G. M. Davis Regulator Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mueller Steam Specialty Co.
O-E Specialty Mfg. Co.
Schutte & Koerting Co.

VALVES, Balanced

James B. Clow & Sons
Crane Co.
G. M. Davis Regulator Co.
Julian D'Este Co.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Minneapolis-Honeywell Regulator Co.
Mueller Steam Specialty Co.

VALVES, Blow-off

American Radiator Co.
Cochrane Corp.
Consolidated Ashcroft Hancock Co., Inc.

Crane Co.
Fairbanks Co.
Jenkins Bros.
United States Radiator Corp.

VALVES, Check

James B. Clow & Sons
Cochrane Corp.
Consolidated Ashcroft Hancock Co., Inc.
Crane Co.
Fairbanks Co.
Grinnell Co., Inc.
Jenkins Bros.
Schutte & Koerting Co.

VALVES, Float

James B. Clow & Sons
Crane Co.
G. M. Davis Regulator Co.
Illinois Engineering Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
McAlear Mfg. Co.
Mueller Steam Specialty Co.
O-E Specialty Mfg. Co.
Schutte & Koerting Co.
Trane Co.

VALVES, Gate

American District Steam Co.
American Radiator Co.
James B. Clow & Sons
Consolidated Ashcroft Hancock Co., Inc.
Crane Co.
Fairbanks Co.
Jenkins Bros.
Marsh Valve Co.
Jas. P. Marsh & Co.
O-E Specialty Mfg. Co.
Schutte & Koerting Co.
United States Radiator Corp.

VALVES, Hydraulic

Consolidated Ashcroft Hancock Co., Inc.
Crane Co.
J. E. Lonergan Co.

VALVES, Non-Return

James B. Clow & Sons
Consolidated Ashcroft Hancock Co., Inc.
Crane Co.
G. M. Davis Regulator Co.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
McAlear Mfg. Co.
Schutte & Koerting Co.

VALVES, Pressure Reducing (*See Regulators, Pressure*)

VALVES, Radiator

American District Steam Co.
American Radiator Co.
Barnes & Jones
Bishop & Babcock Sales Co.
Crane Co.
Direct Control Valve Co.
C. A. Dunham Co.
Fairbanks Co.
Grinnell Co., Inc.
Wm. S. Haines & Co.
Hoffman Specialty Co.
Illinois Engineering Co.
Jenkins Bros.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
Marsh Valve Co.
Jas. P. Marsh & Co.
O-E Specialty Mfg. Co.
Wm. H. Page Boiler Co.
Pierce, Butler & Pierce Mfg. Corp.
Richardson & Boynton Co.
W. A. Russell & Co.
Sarco Co., Inc.
Sterling Engineering Co.
Trane Co.
United States Radiator Corp.
Vapor Engineering Co.
Warren Webster & Co.

VALVES, Relief

American Radiator Co.
Cochrane Corp.
Consolidated Ashcroft Hancock Co., Inc.
Crane Co.
G. M. Davis Regulator Co.
D. & T. Mfg. Co.
Julian D'Este Co.
Illinois Engineering Co.
Kainer & Co.
Kieley & Mueller, Inc.
Klipfel Mfg. Co.
J. E. Lonergan Co.
Jas. P. Marsh & Co.
McAlear Mfg. Co.
Mueller Co.
Mueller Steam Specialty Co.
Neptune Meter Co.
O-E Specialty Mfg. Co.
Petroleum Heat & Power Co.
Richardson & Boynton Co.
Swartwout Co.
H. A. Thrush & Co.
Time-O-Stat Controls Co.
United States Radiator Corp.

VALVES, Safety

American District Steam Co.
American Radiator Co.
Consolidated Ashcroft Hancock Co., Inc.
Crane Co.
Jenkins Bros.
J. E. Lonergan Co.
Jas. P. Marsh & Co.
New York Air Valve Corp.
O-E Specialty Mfg. Co.
Wm. H. Page Boiler Co.
Richardson & Boynton Co.
United States Radiator Corp.

VALVES, Stop and Check (*See Valves, Non-Return*)

VAPOR HEATING SYSTEMS (*See Heating Systems, Vapor*)

VENTILATORS, Floor and Wall

American Blower Corp.
Auer Register Co.
Johnson Fan & Blower Co.
Knowles Mushroom Ventilator Co.
L. J. Mueller Furnace Co.
B. F. Sturtevant Co.
Tuttle & Bailey Mfg. Co.

VENTILATORS, Mushroom

American Blower Corp.
Knowles Mushroom Ventilator Co.
L. J. Mueller Furnace Co.

VENTILATORS, Roof

American Blower Corp.
W. F. Hirschman Co., Inc.
Ilg Electric Ventilating Co.
Johnson Fan & Blower Co.
Niagara Blower Co.
Skinner Bros. Mfg. Co., Inc.
B. F. Sturtevant Co.
Swartwout Co.

VENTILATORS, Unit

American Blower Corp.
Bishop & Babcock Sales Co.
Buckeye Blower Co.
Ilg Electric Ventilating Co.
Herman Nelson Corp.
John J. Nesbitt, Inc.
New York Blower Co.
Peerless Unit Ventilation Co., Inc.
Reed Air Filter Co., Inc.
B. F. Sturtevant Co.

WARM AIR FURNACES (*See Furnaces, Warm Air*)

WARM AIR HEATING SYSTEMS (*See Heating Systems, Furnace*)

WATER FEEDERS (*See Feeders, Water*)

WATER HEATERS, (*See Heaters, Hot Water Service*)

WATER SOFTENERS (*See Softeners, Water*)

WEATHER STRIPS, Metal

Higgin Mfg. Co.

WELDING AND CUTTING APPARATUS

Bastian-Blessing Co.

Catalog Data of Manufacturers listed can be located by referring to pages 885 to 888

Index to Advertisers

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS GUIDE 1930

	Page
Aerofin Corporation, 850 Frelinghuysen Ave., Newark, N. J.	700–701
Air-Way Electric Appliance Corp., Toledo, Ohio	658–659
Alberger Heater Co., 218 Chicago St., Buffalo, N. Y.	682
American Air Filter Co., 215 Central Ave., Louisville, Ky.	546, 547, 548, 656
American Blower Corp., Detroit, Mich.	637
American District Steam Co., North Tonawanda, N. Y.	635
American Gas Products Corp., 376 Lafayette St., New York, N. Y.	553
American Radiator Co., 40 West 40th St., New York, N. Y.	559–569, 702–704
American Society of Heating & Ventilating Engrs., 29 West 39th St., New York, N. Y.	752
American Steam Pump Co., Battle Creek, Mich.	753
Ames Iron Works, Oswego, N. Y.	607
Armstrong Cork & Insulation Co., Lancaster, Pa.	650, 722–723
Auer Register Co., 3608 Payne Ave., Cleveland, Ohio	777
Automatic Burner Corp., 312 N. May St., Chicago, Ill.	625
E. B. Badger & Sons Co., 75 Pitts St., Boston, Mass.	636
Bahnson Co., Winston-Salem, N. C.	717
Barnes & Jones, 128 Brookside Ave., Jamaica Plain, Boston, Mass.	779
Bastian-Blessing Co., 240 E. Ontario St., Chicago, Ill.	874
Bayley Blower Co., 784 Greenbush St., Milwaukee, Wis.	638
Bell & Gossett Co., 3000 Wallace St., Chicago, Ill.	683
Bigelow Company, New Haven, Conn.	570–571
Bishop & Babcock Sales Co., 4901-4915 Hamilton Ave., N.E., Cleveland, Ohio	780
Brownell Co., Dayton, Ohio	572–574
Bryant Heater & Mfg. Co., 17850 St. Clair Ave., Cleveland, Ohio	554–556
Buckeye Blower Co., 400 Dublin Ave., Columbus, Ohio	639
Buffalo Forge Co., 450 Broadway, Buffalo, N. Y.	640
Buffalo Steam Pump Co., 450 Broadway, Buffalo, N. Y.	754
Builders Iron Foundry, 9 Codding St., Providence, R. I.	743
Burnham Boiler Corporation, Irvington-on-Hudson, N. Y.	575
Samuel Cabot, Inc., 141 Milk St., Boston, Mass.	721
Carrier Engineering Corp., 850 Frelinghuysen Ave., Newark, N. J.	534–535
Carrier-Lyle Corp., 850 Frelinghuysen Ave., Newark, N. J.	691–692
Celotex Co., 919 N. Michigan Ave., Chicago, Ill.	724–725
Central Radiator Co., 420 Lexington Ave., New York, N. Y.	577
Chicago Mill & Lumber Corp., 111 W. Washington St., Chicago, Ill.	728
Chicago Pump Co., 2330 Wolfram St., Chicago, Ill.	756–757
Circulair Heat, Inc., 202 Central Ave., Louisville, Ky.	656
James B. Clow & Sons, 211 N. Talman Ave., Chicago, Ill.	772–773
Coatesville Boiler Works, Coatesville, Pa.	576
Cochrane Corporation, 3120 North 17th St., Philadelphia, Pa.	781
Combustion Specialties Corp., 101-109 East 144th St., New York, N. Y.	782
Consolidated Ashcroft Hancock Co., Inc. (American Schaeffer & Budenburg Division), Bridgeport, Conn.	718
Cooling & Air Conditioning Corp., 11 West 42nd St., New York, N. Y.	536
Crane Co., 836 S. Michigan Ave., Chicago, Ill.	858, 859
D. & T. Mfg. Co., 3001-3009 La Salle St.; St. Louis, Mo.	712
Davis Engineering Corp., 90 West St., New York, N. Y.	684
G. M. Davis Regulator Co., 407 Milwaukee Ave., Chicago, Ill.	783
De Bothezat Impeller Co., Inc., 1922 Park Ave., New York, N. Y.	641

Page

Decatur Pump Co., Decatur, Ill. 755
Julian D'Este Company, 6 Spice St., Charlestown Dist., Boston, Mass. 797
Detroit Stoker Co., 3-168 General Motors Bldg., Detroit, Mich. 549
Direct Control Valve Co., 8 S. Michigan Ave., Chicago, Ill. 860–861
Dixie Blower Co., 1351 West 37th Place, Chicago, Ill. 657
C. A. Dunham Co., 450 E. Ohio St., Chicago, Ill. 784–796

Economy Pumping Machinery Co., 3431 West 48th Place, Chicago, Ill. 758–759
Edge Moor Iron Co., Edge Moor, Delaware 578–579
Electrol Incorporated, 227 East 45th St., New York, N. Y. 626
Ellison Draft Gage Co., 214 W. Kinzie St., Chicago, Ill. 652–653
Erie City Iron Works, 1500 East Ave., Erie, Pa. 582
Excelso Products Corp., 65 Clyde Ave., Buffalo, N. Y. 686–687

Fairbanks Co., 393 Lafayette St., New York, N. Y. 863
Fitzgibbons Boiler Co., Inc., 570 Seventh Ave., New York, N. Y. 580–581
Flax-li-num Insulating Co., St. Paul, Minn. 726–727
O. E. Frank Heater & Engineering Co., Inc., 20 Milburn St., Buffalo, N. Y. 685

Garden City Fan Co., McCormick Bldg., Chicago, Ill. 642
General Electric Co., 1 River Road, Schenectady, N. Y. 746–747
Goulds Pumps, Inc., Seneca Falls, N. Y. 760–761
Grinnell Co., Inc., Providence, R. I. 693–699, 862

Wm. S. Haines & Co., 12th and Buttonwood Sts., Philadelphia, Pa. 798
Hardinge Brothers, Inc., 4149 Ravenswood Ave., Chicago, Ill. 627
Harrisburg Star Boiler Corp., 15 Park Row, New York, N. Y. 586
Healy-Ruff Co., 776 Hampden Ave., St. Paul, Minn. 775
Heating & Ventilating, 521 Fifth Ave., New York, N. Y. 751
Heggie-Simplex Boiler Co., Joliet, Ill. 583–585
Higgin Mfg. Co., Newport, Ky. 744–745
E. Vernon Hill Co., 121 N. Clark St., Chicago, Ill. 719
W. F. Hirschman Co., Inc., 220 Delaware Ave., Buffalo, N. Y. 870–872
Hoffman Specialty Co., Inc., Waterbury, Conn. 799–808

Ilg Electric Ventilating Co., 2880 N. Crawford Ave., Chicago, Ill. 643
Illinois Engineering Co., 21st St. and Racine Ave., Chicago, Ill. 810–811
Insulite Co., Minneapolis, Minn. 729
International Fibre Board, Ltd., 1111 Beaver Hall Hill, Montreal, Que., Can., 730–731
Iron Fireman Mfg. Co., Portland, Oregon 550–551

Jenkins Bros., 80 White St., New York, N. Y. 868
Johns-Manville Corp., 292 Madison Ave., New York, N. Y. 740
Johnson Fan & Blower Co., 1317 W. Lake St., Chicago, Ill. 644
Johnson Service Co., 149-159 E. Michigan St., Milwaukee, Wis. 847–850

Kainer & Co., 761–771 Mather St., Chicago, Ill. 713
Keasbey & Mattison Co., Ambler, Pa. 741
Kelly Brass Works, 226-232 W. Ontario St., Chicago, Ill. 809
Kewanee Boiler Corp., Kewanee, Ill. 587–593
Kieley & Mueller, Inc., 34 West 13th St., New York, N. Y. 814
Klipfel Mfg. Co., 2641–2659 W. Harrison St., Chicago, Ill. 812–813
Knowles Mushroom Ventilator Co., 41 N. Moore St., New York, N. Y. 544
Knowles Pipe Sleeve Co., 41 N. Moore St., New York, N. Y. 545

Langenberg Mfg. Co., 4549 N. Euclid Ave., St. Louis, Mo. 651
Leader Boiler & Heater Co., 310 S. Michigan Ave., Chicago, Ill. 594
J. E. Lonergan Co., 211-215 Race St., Philadelphia, Pa. 816–817

Page
MacAndrews & Forbes Co., 200 Fifth Ave., New York, N. Y. 732
Jas. P. Marsh & Co., 2073 Southport Ave., Chicago, Ill. 818–830
Marsh Valve Co., Dunkirk, N. Y. 864–867
Maryland Air Conditioning Corp., Clarkson, McComas, Donaldson and Race Sts., Baltimore, Md. 537
Masonite Corporation, 111 W. Washington St., Chicago, Ill. 733
May Oil Burner Corp., Baltimore, Md. 628–629
McAlear Mfg. Co., 1901 S. Western Ave., Chicago, Ill. 815
McCord Radiator & Mfg. Co., 2587 E. Grand Blvd., Detroit, Mich. 705
McDonnell & Miller, Wrigley Bldg., Chicago, Ill. 624
McQuay Radiator Corp., 35 E. Wacker Drive, Chicago, Ill. 660–662
Midwest Mfg. Co., Bradford, Pa. 546
Minneapolis-Honeywell Regulator Co., 2711 Fourth Ave., S., Minneapolis, Minn. 856–857
Molby Boiler Co., Inc., 420 Lexington Ave., New York, N. Y. 595
Monash-Younker Co., Inc., 1315 W. Congress St., Chicago, Ill. 832–833
Monitor Boiler Co., 1505 Race St., Philadelphia, Pa. 596–597
Mueller Co., Decatur, Ill. 714
L. J. Mueller Furnace Co., 200 Reed St., Milwaukee, Wis. 557
Mueller Steam Specialty Co., Inc., 349-351 West 26th St., New York, N. Y. 831

Nash Engineering Co., South Norwalk, Conn. 762–763
National Air Filter Co., 205 Central Ave., Louisville, Ky. 547
National Radiator Corp., 55 West 42nd St., New York, N. Y. 598–600, 774
National Regulator Co., 2311 Knox Ave., Chicago, Ill. 851
Herman Nelson Corp., Moline, Ill. 663–666
Neptune Meter Co., 50 East 42nd St., New York, N. Y. 715
John J. Nesbitt, Inc., Holmesburg Junction, Philadelphia, Pa. 667–670
Newport Boiler Co., 529 S. Franklin St., Chicago, Ill. 601
New York Air Valve Corp., 476-478 Broome St., New York, N. Y. 869
New York Blower Co., 3169 Shields Ave., Chicago, Ill. 645
Niagara Blower Co., 673 Ontario St., Buffalo, N. Y. 538-539

O-E Specialty Mfg. Co., 1710–1712 St. Paul Ave., Milwaukee, Wis. 834
Oil City Boiler Works, Oil City, Pa. 602–603

Pacific Steel Boiler Corp., Waukegan, Ill. 604–605
Wm. H. Page Boiler Co., 200 Madison Ave., New York, N. Y. 606
Palmer Co., 426 Clay St., Cincinnati (St. Bernard), Ohio 720
Parks-Cramer Co., Fitchburg, Mass. 540–541
Patterson-Kelley Co., 99 Park Ave., New York, N. Y. 688
Peerless Unit Ventilation Co., Inc., 776-788 Union Ave., Bridgeport, Conn. 671–673
Pennrich & Co., Inc., 29 Broadway, New York, N. Y. 734
Petroleum Heat & Power Co., Stamford, Conn. 630
Pierce, Butler & Pierce Mfg. Corp., 41 East 42nd St., New York, N. Y. 608–609
Pittsburg Water Heater Co., Pittsburgh, Pa. 558
Powers Regulator Co., 2719 Greenview Ave., Chicago, Ill. 852–855

Reed Air Filter Co., Inc., 202 Central Ave., Louisville, Ky. 548
Richardson & Boynton Co., 260 Fifth Ave., New York, N. Y. 616
Richmond Radiator Co., Inc., 1480 Broadway, New York, N. Y. 610–611
Ric-wiL Co., Union Trust Bldg., Cleveland, Ohio 742
Rochester Circulator Co., 3092 Culver Road, P. O. Box 23, Rochester, N. Y. 764
Rome Brass Radiator Corp., 1 East 42nd St., New York, N. Y. 768–771
Rome-Turney Radiator Co., Rome, N. Y. 706
W. A. Russell & Co., Grand Central Terminal, New York, N. Y. 835

	Page
Sarco Co., Inc., 183 Madison Ave., New York, N. Y.	836–837
Schleicher, Inc., 3824 Georgia St., Gary, Ind.	767
Schutte & Koerting Co., 1154 Thompson St., Philadelphia, Pa.	707
Skidmore Corp., 1535 Dayton St., Chicago, Ill.	765
Skinner Bros. Mfg. Co., Inc., 1490 S. Vandeventer, St. Louis, Mo.	674–675
Spencer Heater Co., Williamsport, Pa.	612–613
Sprayo-Flake Co., 56 S. Bay St., Milwaukee, Wis.	735
Stanwood Corporation, P. O. Box 821, Cincinnati, Ohio	614–615
Sterling Engineering Co., 1626-44 Holton St., Milwaukee, Wis.	840
Stewart InsoBoard Co., St. Joseph, Mo.	738
Stockham Pipe & Fittings Co., Birmingham, Ala.	750
Strandwitz & Scott, Inc., 537-49 S. Second St., Camden, N. J.	543
B. F. Sturtevant Co., Hyde Park, Boston, Mass.	646
Swartwout Co., 18551 Euclid Ave., Cleveland, Ohio	873
Webster Tallmadge & Co., Inc., 50 Church St., New York, N. Y.	846
Texo Heater & Mfg. Corp., 220-230 Madison Ave., Covington, Ky.	676
Thermal Units Co., Pershing Road and Loomis St., Chicago, Ill.	677
Thermidaire Corporation, 2441-45 Charlotte St., Kansas City, Mo.	678
Therm-O-Proof Insulation Co., 203 N. Wabash Ave., Chicago, Ill.	739
H. A. Thrush & Co., Peru, Ind.	716
Time-O-Stat Controls Co., Elkhart, Ind.	634
Titusville Iron Works Co., Titusville, Pa.	617
Trane Co., La Crosse, Wis.	654–655, 679, 766, 838–839
Tuttle & Bailey Mfg. Co., 441 Lexington Ave., New York, N. Y.	778
Unit Heater & Cooler Co., Wausau, Wis.	680
United States Ozone Co., 500 N. Dearborn St., Chicago, Ill.	749
United States Radiator Corp., Detroit, Mich.	618–620
Vapor Engineering Co., 489 Fifth Ave., New York, N. Y.	841
Vinco Co., Inc., 75 Vesey St., New York, N. Y.	623
Warren Webster & Co., Camden, N. J.	842–844
Weil-McLain Co., 641 W. Lake St., Chicago, Ill.	621
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.	748
Whiting Corporation (Harrington Division), Harvey, Ill.	552
Whitlock Coil Pipe Co., Hartford, Conn.	689–690
Wickes Boiler Co., Saginaw, Mich.	622
Williams-Oil-O-Matic Heating Corp., Bloomington, Ill.	632–633
Winchester Repeating Arms Co., New Haven, Conn.	708–709
L. J. Wing Mfg. Co., 59 Seventh Ave., New York, N. Y.	647–649
Winslow Boiler & Engineering Co., 844 Rush St., Chicago, Ill.	631
Wolverine Tube Co., 1453 Central Ave., Detroit, Mich.	710
Wood Conversion Co., Cloquet, Minn.	736–737
Wright-Austin Co., 315 W. Woodbridge St., Detroit, Mich.	845
York Heating & Ventilating Corp., 16th and Sansom Sts., Philadelphia, Pa.,	542, 681, 711
York Ice Machinery Corp., York, Pa.	776

Roll of Membership

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1929-30

Contains Lists of Members Arranged Alphabetically and Geographically also Lists of Officers and Committees, Past Officers and Local Chapter Officers

Corrected to December 1, 1929

Published at the Headquarters of the Society
29 West 39th Street, New York, N. Y.

Officers and Council

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1929

President	THORNTON LEWIS
First Vice-President	L. A. HARDING
Second Vice-President	W. H. CARRIER
Treasurer	W. E. GILLHAM
Secretary	A. V. HUTCHINSON
Technical Secretary	P. D. CLOSE

Council

THORNTON LEWIS, *Chairman*
L. A. HARDING, *Vice-Chairman*

One Year	*Two Years*	*Three Years*
W. H. CARRIER	H. H. ANGUS	E. B. LANGENBERG
C. V. HAYNES	N. W. DOWNES	G. L. LARSON
JOHN HOWATT	ROSWELL FARNHAM	F. C. MCINTOSH
W. T. JONES	F. B. ROWLEY	W. A. ROWE
A. C. WILLARD		

Committees of the Council

Executive: L. A. Harding, *Chairman;* W. H. Carrier, W. E. Gillham.
Finance: W. T. Jones, *Chairman;* C. V. Haynes, F. C. McIntosh.
Membership: Roswell Farnham, *Chairman;* John Howatt, G. L. Larson.
Publication: A. C. Willard, *Chairman;* N. W. Downes, W. A. Rowe.

Advisory Council

A. C. Willard, *Chairman;* Homer Addams, F. Paul Anderson, R. P. Bolton, S. E. Dibble, W. H. Driscoll, H. P. Gant, John F. Hale, H. M. Hart, E. Vernon Hill, J. D. Hoffman, S. A. Jellett, D. D. Kimball, S. R. Lewis, J. I. Lyle, J. R. McColl, D. M. Quay, C. L. Riley and F. R. Still.

Special Committees

Advisory Committee on International Heating and Ventilating Exposition: H. P. Gant, *Chairman;* E. B. Langenberg, J. I. Lyle, J. F. McIntire, F. R. Still, H. L. Whitelaw, E. K. Webster, H. C. Murphy, A. S. Armagnac, D. S. Boyden, A. C. Edgar, C. V. Haynes, W. H. Carrier and Roswell Farnham.

Guide Publication Committee: S. R. Lewis, *Chairman;* W. H. Carrier, C. V. Haynes and J. F. McIntire.

Committee on Meetings Program: H. H. Angus, *Chairman;* A. J. Nesbitt and F. B. Rowley.

Committee on Code for Testing Unit Heaters: D. E. French, *Chairman;* L. C. Soule, W. A. Rowe and H. W. Page; representing *Industrial Unit Heater Association:* G. E. Otis, *Chairman;* O. K. Dyer and J. H. Shrock.

Committee for Interpreting Code for Rating Low-Pressure Heating Boilers: L. A. Harding, *Chairman;* R. V. Frost and F. C. Houghten.

Committee to Prepare Code for Testing and Rating Concealed Radiators: G. E. Otis, *Chairman;* W. H. Carrier, R. N. Trane, R. C. Malvin and F. C. Houghten.

Committees—1929

Committee on Research

L. A. Harding, *Chairman*
S. R. Lewis, *Vice-Chairman*

F. C. Houghten, *Director*
O. P. Hood, *Ex-Officio Member*

One Year	*Two Years*	*Three Years*
Philip Drinker	A. R. Acheson	O. W. Armspach
S. R. Lewis	D. S. Boyden	R. S. Franklin
F. D. Mensing	R. V. Frost	F. E. Giesecke
W. A. Rowe	L. A. Harding	A. P. Kratz
A. C. Willard	F. B. Rowley	A. E. Stacey

Coördinated Research: J. C. Fitts, *Chairman* (*Nat'l Assn. H. & P. Contrs.*); R. M. Conner (*American Gas Association*).

Technical Advisory Committees

Temperature, Humidity and Air Motion: W. H. Carrier, *Chairman;* O. W. Armspach, S. C. Bloom, C. A. Bulkeley, Philip Drinker, W. A. Rowe and Perry West.

Infiltration: G. L. Larson, *Chairman;* A. W. King, A. P. Kratz, L. B. Lent and W. C. Randall.

Heat Transmission: A. P. Kratz, *Chairman;* D. R. Brewster, F. B. Rowley, C. G. Segeler and Perry West.

Pipe Sizes for Heating Systems: H. M. Hart, *Chairman;* S. E. Dibble, R. S. Franklin, F. E. Giesecke, C. V. Haynes and R. C. Morgan.

Heating and Ventilation in Its Relation to Health and Comfort: Philip Drinker, *Chairman;* John Aeberly, O. W. Armspach and C. P. Yaglou.

Radiation: R. A. Wolff, *Chairman;* C. W. Brabbée, R. V. Frost, J. D. Hoffman, C. H. B. Hotchkiss, J. F. McIntire, F. D. Mensing and A. C. Willard.

Garage Ventilation: E. K. Campbell, *Chairman;* W. H. Carrier, E. B. Langenberg and Thornton Lewis.

Air Cleaning Devices: F. B. Rowley, *Chairman;* H. E. Birkholz, Albert Buenger, E. V. Hill and H. C. Murphy.

Atmospheric Dust and Smoke: E. B. Langenberg, *Chairman;* E. V. Hill, S. R. Lewis and H. C. Murphy.

Oil Burning Devices: L. E. Seeley, *Chairman;* James Breese, Jr., G. S. Meikle and H. L. Tapp.

Effect of Wind and Weather Conditions on the Heating Loads: R. S. Franklin, *Chairman;* W. L. Fleisher, J. F. Hale, E. B. Langenberg, S. R. Lewis, F. R. Still and A. C. Willard.

Testing and Rating Unit Heaters: D. E. French, *Chairman;* O. K. Dyer, G. E. Otis, H. W. Page, W. A. Rowe, J. H. Shrock and L. C. Soule.

Officers of Local Chapters

1929-30

Cleveland

Headquarters, Cleveland

Meets: Second Friday in Month

President, W. C. Kammerer
1301 Citizens Bldg.
Secretary, R. G. Davis
887 Nela View Road

Illinois

Headquarters, Chicago

Meets: Second Monday in Month

President, H. G. Thomas
549 W. Washington Blvd.
Secretary, C. W. Deland
211 N. Desplaines Street

Kansas City

Headquarters, Kansas City, Mo.

Meets: Second Monday in Month

President, C. C. Clegg
311 Mutual Bldg.
Secretary, F. A. Kitchen
1011 Pioneer Trust Bldg.

Massachusetts

Headquarters, Boston

Meets: First Monday in Month

President, T. F. McCoy
125 St. Botolph Street
Secretary, J. S. Webb
Statler Bldg., Room 517

Michigan

Headquarters, Detroit

Meets: First Monday after the 10th of the Month

President, W. G. Boales
1346 Broadway, Room 502
Secretary, E. H. Clark
606 Michigan Theater Bldg.

Minnesota

Headquarters, Minneapolis

Meets: Second Monday in Month

President, E. F. Jones
301 Zenith Bldg., St. Paul, Minn.
Secretary, M. S. Wunderlich
2095 James Street, St. Paul

New York

Headquarters, New York

Meets: Third Monday in Month

President, E. J. Ritchie
183 Madison Ave.
Secretary, E. B. Johnson
154 Wardwell Ave., W. New Brighton, S. I.

Western New York

Headquarters, Buffalo

Meets: First Monday in Month

President, O. K. Dyer
490 Broadway
Secretary, D. J. Mahoney
503 Franklin Street

Ontario

Headquarters, Toronto, Canada

Meets: First Monday in Month

President, M. Barry Watson
25 Bloor Street
Secretary, J. Paterson
155 College Street

Pacific Northwest

Headquarters, Seattle, Wash.

Meets: Second Thursday in Month

President, E. L. Weber
723 Seaboard Bldg.
Secretary, M. Anderson
246 Westmont Way

Philadelphia

Headquarters, Philadelphia

Meets: Second Thursday in Month

President, A. C. Edgar
1202 Locust Street
Secretary, L. C. Davidson
810 Land Title Bldg.

Pittsburgh

Headquarters, Pittsburgh

Meets: First Monday in Month

President, H. Lee Moore
927 Union Trust Bldg.
Secretary, W. W. Teague
4800 Forbes Street

St. Louis

Headquarters, St. Louis

Meets: First Wednesday in Month

President, F. J. McMorran
230 E. Argonne Drive, Kirkwood, Mo.
Secretary, R. M. Rosebrough
4246 Forest Park Blvd.

Wisconsin

Headquarters, Milwaukee

Meets: Third Monday in Month

President, F. G. Weimer
440 Barclay Street
Secretary, V. A. Berghoefer
1640 Holton Street

Roll of Membership

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1929-30

HONORARY MEMBERS

BALDWIN, WM. J. (1915), New York, N. Y. (Deceased May 7, 1924.)
BILLINGS, DR. J. S. (1896), New York, N. Y. (Deceased March 10, 1913.)
GORMLY, JOHN (Charter Member), Norristown, Pa. (Deceased January 31, 1929.)
NEWTON, C. W. (Charter Member), Baltimore, Md. (Deceased August 6, 1920.)
HOOD, O. P. (1929), Washington, D. C.
JELLETT, STEWART A. (Charter Member), (Presidential Member), Philadelphia, Pa.

LIST OF MEMBERS IN GOOD STANDING

Arranged Alphabetically—All Grades

(Asterisk indicates authorship of papers)

(*M* **1923**; *A* **1918**; *J* **1916**) indicates, Election as Member 1923; Associate 1918; Junior 1916.
(**Pres. 1923**) indicates, Elected President in 1923 and is now a Presidential Member.

A

ABBOUD, Alfred (*J* 1914), Pres. (for mail), Alfred Abboud & Co., Inc., 45 Bromfield St., Boston, and 4467 Washington St., Roslindale, Mass.

ABEL, D. Morgan (*J* 1928), Research Engr. (for mail), York Htg. & Vtg. Corp., Bridgeport, Montgomery Co., and 103 Jacoby St., Norristown, Pa.

ABRAHAMSON, P. (*M* 1927), Secy. (for mail), Advance Htg. Co., 117 N. Desplaines St., and 1440 Rosemont Ave., Chicago, Ill.

ABRAMS, Abraham (*M* 1927; *J* 1924), 1240 Walton Ave., New York, N. Y.

ACHESON, Albert R. (*M* 1919), Consulting Engr. (for mail), 601 Eckel Theater Bldg., and 852 Ostrom Ave., Syracuse, N. Y.

ADAMS, Benjamin (*M* 1919), Dist. Mgr. (for mail), American Blower Corp., 612 Otis Bldg., and 3006 W. Coulter St., Queen Lane Manor, Philadelphia, Pa.

ADAMS, Charles W. (*M* 1920), Vice-Pres. (for mail), The Daly Co., 1635 Blake St., and Denver Athletic Club, Denver, Colo.

ADAMS, N. D. (*A* 1925; *J* 1922), Supt. (for mail), Franklin Htg. Sta., 220 Second Ave. S. W., and 836 Eighth Ave. S. W., Rochester, Minn.

ADDAMS, Homer (*Charter Member*), (*Presidential Member*), Pres., 1924; 1st Vice-Pres., 1923; Treas., 1915-1922; Council, 1915-1925), Pres. (for mail), Kewanee Boiler Co., Inc., 570 Seventh Ave., New York, N. Y.

ADDY, Edward (*M* 1923), Board of Education, 155 College St., Toronto, Ont., Can.

ADLER, Alphonse A.* (*M* 1921), Consulting Engr. (for mail), 10 Murray St., New York, N. Y., and 35 Stewart Ave., Arlington, N. J.

ADRIANSE, Paul R. (*M* 1923), Dist. Mgr. (for mail), Buffalo Forge Co., 610 Pershing Sq. Bldg., Los Angeles, Calif.

AEBERLY, John J.* (*M* 1928), 6015 Newburg Ave., Norwood Park, Chicago, Ill.

AHEARN, William J. (*M* 1929), The Downey Co., 99 W. Dedham St., Boston, Mass.

AHERN, Thomas L. (*M* 1928; *A* 1928; *J* 1923), John F. Ahern Co., 80 S. Portland St., Fond du Lac, Wis.

AHLFF, Albert A. (*M* 1923; *A* 1918), 521 Crescent Ave., Buffalo, N. Y.

AKERS, George W. (*M* 1929), Secy-Treas., Geo. W. Akers Co., 2847 Grand River Ave., and (for mail), 3480 Chicago Blvd., Detroit, Mich.

ALCOTT, William L. (*A* 1929), 945 Liberty Ave., Pittsburgh, Pa.

ALEXANDER, Alfred D. (*M* 1915), 168 Marion St., Oak Park, Ill.

ALEXANDER, Charles H. (*M* 1920), Prop. and Owner (for mail), Charles H. Alexander Co., 313-319 Allen St. N. W., and 532 Paris Ave. S. E., Grand Rapids, Mich.

ALGER, Richard W. (*M* 1911), Member of Firm (for mail), Marye, Alger & Vinour, 801-7 Walton Bldg., and 40–15th St. N. E., Apt. J., Atlanta, Ga.

ALLAN, Charles D. (*M* 1920), 612 N. Michigan Ave., Chicago, Ill.

ALLEN, Harry D. (*M* 1917), Htg. Contractor (for mail), 2940 W. Lake St., and 1640 N. Luna Ave., Chicago, Ill.

ALLEN, W. Harwell (*M* 1911; *J* 1910), Pres. (for mail), State Htg. & Power Co., 272 Walnut St., P. O. Box 331, and 878 Kensington Pl., Memphis, Tenn.

ALLINSON, Orrie H. (*M* 1915), Jobstown, N. J.

ALT, Harold L. (*M* 1913), 1926 North 17th St., Philadelphia, Pa.

ALVORD, Arthur M. (*M* 1926), Pres. (for mail), Alvord and Swift, Grand Central Terminal, New York, and 240 Hamilton Ave., New Rochelle, N. Y.

AMES, Charles Fordyce (*A* 1928), Vice-Pres. and Gen. Mgr. (for mail), Ames Pump Co., Inc., 30 Church St., New York, N. Y., and 4312 Allendale Ave., Detroit, Mich.

AMMERMAN, Charles R. (*M* 1916), Consulting Engr. (for mail), 924 Continental Bk. Bldg., and 3908 Guilford Ave., Indianapolis, Ind.

ANDEL, Frank J. (*M* 1922), Andel & Co., 4630 N. Lamon Ave., Chicago, Ill.

ANDEREGG, R. H. (*M* 1920), Central Div. Sales Mgr., The Trane Co., and (for mail), Apt. 102, Kingston Court, La Crosse, Wis.

ANDERSON, Claude A. (*M* 1916), Dist. Mgr., Johnson Fan and Blower Co., 613 Harrison Bldg., Philadelphia, and (for mail), 218 W. Washington Lane, Germantown, Philadelphia, Pa.

ANDERSON, F. Paul* (*M* 1921), (*Presidential Member*), (Pres., 1927; 1st Vice- Pres., 1926; 2nd Vice-Pres., 1925; Council, 1924-1928), (for mail), Dean, College of Engineering, University of Kentucky, and 499 E. Main St., Lexington, Ky.

ANDERSON, Marius (*M* 1929), Mech. Engr., Seattle School District No. 1, 810 Dexter Ave., and (for mail), 2467 Westmont Way, Seattle, Wash.

ANDERSON, P. E. (*A* 1926), Buyer (for mail), Farwell, Ozmon, Kirk & Co., Second and Jackson Sts., and 1160 Orange St., St. Paul, Minn.

ANDERSON, S. A., Jr. (*M* 1909), P. O. Box 486, La Grande, Ore.

ANDRESEN, A. W. (*M* 1926), Owner, A. W. Andresen Co., 5311 Penn Ave. S., Minneapolis, Minn.

ANGUS, H. H. (*M* 1918), (Council, 1927-1929), Consulting Engr., Angus & Watson, 25 Bloor St., West Toronto, and (for mail), 34 Farnham Ave., Toronto, Ont., Can.

ARCHER, Frank S. (*A* 1929; *J* 1926), Mfrs. Repr. (for mail), 311 Jackson Bldg., Buffalo, and 110 Chateau Ter., Snyder, N. Y.

ARENBERG, Milton K. (*A* 1920), Chicago Sales Mgr. (for mail), Ilg Elec. Vtg. Co., 324 W. Monroe St., Chicago, and 362 Oakland Dr., Highland Park, Ill.

ARKLEY, L. M.* (*M* 1922), Prof., Queens University, Kingston, Ont., Can.

ARKO, Frank W. (*J* 1929), Research Engr. (for mail), York Htg. & Vtg. Corp., Bridgeport, and 512 Chain St., Norristown, Pa.

ARMAGNAC, Arthur S. (*M* 1914; *A* 1907), Editor (for mail), *Heating and Ventilating*, 521 Fifth Ave., New York, N. Y., and 375 Upper Mountain Ave., Upper Montclair, N. J.

ARMSPACH, O. W.* (*M* 1919), Engr. (for mail), Brunswick-Kroeschell Co., 136 Liberty St., New York, and 3706–72nd St., Jackson Heights, L. I., N. Y.

ARMSTRONG, Harold Melotte (*A* 1928), (for mail), American Radiator Co., 1344 Broadway, and 2921 Webb Ave., Detroit, Mich.

ARNOLD, Robert S. (*A* 1926; *J* 1922), York Htg. & Vtg. Corp., York Bldg., 16th and Sansom Sts., Philadelphia, Pa.

ARONSON, Henry H. (*J* 1929), Asst. Mgr. (for mail), H. A. Aronson & Son, 1015 Chestnut St., and 4740 Pine St., Philadelphia, Pa.

ARTHUR, Harry W. (*A* 1920), 748 S. Flower St., Los Angeles, Calif.

ARTHUR, John M., Jr. (*M* 1923), Industrial Engr. (for mail), Kansas City Power & Light Co., 1330 Grand Ave., Kansas City, Mo., and 3311 State Ave., Kansas City, Kan.

ASCHER, Norman C. (*A* 1928), U. S. Radiator Corp., 516 Board of Trade Bldg., Indianapolis, Ind.

ASHENHURST, Harold S.* (*A* 1926), Consulting Engr., 6519 Algonquin Ave., Chicago, Ill.

ASHLEY, Edward E. (*M* 1912), P. O. Box 188, Noroton Heights, Conn.

ASHTON, David W. (*M* 1929), Htg. Contractor and Engr. (for mail), D. W. Ashton Co., 1529 Main St., and 206 Linden Ave., Buffalo, N. Y.

ASTON, James (*M* 1919), A. M. Buyers Co., 235 Water St., Pittsburgh, Pa.

ATKINSON, Raymond E. (*A* 1928; *J* 1923), P. O. Box 245, Arlington Heights, Ill.

ATWATER, Lyman W. (*M* 1923), Htg. Engr., 552 Rugby Rd., Brooklyn, N. Y.

AUSTIN, Frank L. (1914), 240 College St., Burlington, Vt.

AUSTIN, William E. (*M* 1909), Branch Mgr. (for mail), National Radiator Corp., 3032 Norfolk St., and 107 Overbrook Rd., Richmond, Va.

AXEMAN, James E. (*J* 1925), Sales Engr., Spencer Heater Co., Williamsport, Pa., and (for mail), 162 Spruce Ave., Rochester, N. Y.

B

BABBITT, Edward C. (*M* 1923), 135 N. Ardmore Rd., Columbus, O.

BACHLER, Harry C. (*M* 1927: *J* 1921), Member of Firm (for mail), C. F. Bachler & Son, 139 N. Fourth St., Philadelphia, and 836 Kenmore Rd., Overbrook, Philadelphia, Pa.

BACHLER, Leonard J. (*M* 1918), Engr., Molby Boiler Co., 420 Lexington Ave., and (for mail), 304 East 41st St., New York, N. Y.

BACKSTROM, Russell E. (*J* 1928), Engr., Wood Conversion Co., Cloquet, Minn.

BACKUS, Theodore H. L. (*M* 1916), Schumacher & Backus, 308 S. Main St., Ann Arbor, Mich.

BAETZ, Henry (*M* 1919), Skinner Bros. Mfg. Co., 1440 S. Vanderventer Ave., St. Louis, Mo.

BAHNSON, Frederic F. (*M* 1917), Vice-Pres. and Chief Engr. (for mail), The Bahnson Co., 1001 S. Marshall St., and 28 Cascade Ave., Winston-Salem, N. C.

BAILEY, Edward P., Jr. (*M* 1925), 2642 N. Moreland Blvd., Cleveland, O.

BAILEY, Joseph H. (*M* 1928; *A* 1927; *J* 1923), Sales Engr. (for mail), Carrier Engrg. Corp., 1032 Burnham Bldg., and 1613 Farwell Ave., Chicago, Ill.

BAIN, James G. (*M* 1920), Pacific Engineering Co., 734 East 12th St., Los Angeles, Calif.

BAIRD, Floyd E., (*M* 1929), Mgr., Atlanta Branch (for mail), Trane Co., 405-6 Southeastern Trust Bldg., Atlanta, and 900 Church St., Marietta, Ga.

BAIRD, F. X. (*A* 1925), Johns-Manville, Inc., 292 Madison Ave., New York, N. Y.

BAKER, Clyde H. (*M* 1928), 3907 Keswick Rd., Baltimore, Md.

BAKER, Edward V. (*M* 1923), Silent Partner, J. H. Olson, 4012 S. State St., and (for mail), 3654 Wentworth Ave., Chicago, Ill.

BAKER, H. W. H. (*M* 1918), Twyford, Ltd., 18 Cruncil Rd., Tientsin, N. China.

BAKER, Howard C. (*M* 1921), Pres. (for mail), Howard C. Baker Co., 128 S. St. Clair St., and 4604 Manorwood Dr., Toledo, O.

BAKER, Roland H. (*M* 1928; *A* 1924), Pres. (for mail), R. H. Baker Co., Inc., Kendall Sq. Bldg., and 19 Garden St., Cambridge, Mass.

BALDWIN, William Howard (*M* 1921), Mgr. Br. 23 (for mail), C. A. Dunham Co., 2988 E. Grand Blvd., and 2662 W. Grand Blvd., Detroit, Mich.

BALSINGER, Harry David (*M* 1927), American Radiator Co., 1008 Pine St., St. Louis, Mo.

BAMPTON, C. Morton (*M* 1919), Vice-Pres. (for mail), Ideal Htg. Co., 915 Gates Ave., Brooklyn, and 8843–192nd St., Hollis Park Gardens, L. I., N. Y.

BARKER, Arthur Henry (*M* 1906), Consulting Engr. (for mail), 100 Victoria St., S. W. 1, Westminster, and Oakhill House, Beckenham, Kent, Eng.

BARNES, Arthur F. (*M* 1921), Mech. Engr. and Owner, Texas Engrg. Co., 839 Electric Bldg., Houston, Tex.

BARNES, Elmer Raymond (*M* 1928), Estimator, Eichler Htg. Co., 2010 Railway Exchange Bldg., and (for mail), 4444 Beethoven, St. Louis, Mo.

BARNES, Ralph B. (*M* 1927), 800 Carpenter Ave., Oak Park, Ill.

BARNSTEINER, Alphons (*A* 1926), Westinghouse Elec. & Mfg. Co., 200 E. Fifth St., Mansfield, O.

BARNUM, Marvin C. (*A* 1928), Sales Mgr., Humidifier Div. (for mail), Wilcolator Co., 17 Nevada St., Newark, N. J., and 1921 Irvine Ave. S., Minneapolis, Minn.

BARR, George W. (*M* 1905), 24 Chatfield Rd., Bronxville, N. Y.

BARRE, Louis S. (*M* 1925), 32 Ave. De La Motte, Picquet 32, Paris, France.

BARROWS, C. E. (*A* 1921), Mgr., Chicago Br., (for mail), Crane Co., 156 N. Jefferson St., Chicago, and 1041 Ridge Ave., Evanston, Ill.

BARRY, Patrick I. (*M* 1920), Htg. Engr. (for mail), M. Barry, Ltd., 4 Marlboro St., and 2 Clarence Ter., St. Lukes, Cork, Ireland.

BARTH, Herbert E. (*M* 1920), Eastern Div. Sales Mgr., American Blower Corp., 50 Church St., New York, N. Y.

BARTLETT, Amos C. (*M* 1919), B. F. Sturtevant Co., 60 State St., Boston, Mass.

BARTLETT, C. Edwin (*M* 1922), Pres. (for mail), Bartlett & Co., Inc., 1938 Market St., and 3111 W. Coulter St., Philadelphia, Pa.

BARTON, Royal Elton (*M* 1922), McLean & Cousens Co., 65 Chandler St., Boston, Mass.

BASSLER, Edwin M. (*M* 1923), D. J. Murray Mfg. Co., 1002 Third St., Wausau, Wis.

BASTEDO, Albert E. (*M* 1919), Burnham Boiler Corp., Irvington, N. Y.

BAUER, Henry C. (*A* 1928), H. C. Bauer Co., 42 E. Allen St., Philadelphia, Pa.

BAUM, Albert L. (*M* 1916), Member of Firm, Jaros & Baum, 116 West 39th St., and (for mail), 255 West 108th St., New York, N. Y.

BAUMGARDNER, Carroll Miles (*M* 1928), Br. Mgr. (for mail), U. S. Radiator Corp., 228 N. La Salle St., Chicago, and 613-B Sheridan Rd., Evanston, Ill.

BAYSE, Harry V. (*M* 1923), American Furnace Co., 2725 Morgan St., St. Louis, Mo.

BEAHM, Robert B. (*M* 1924; *A* 1919), Eagan & Beahm, Inc., 304-5-6 Stephen Girard Bldg., Philadelphia, Pa.

BEASOM, George R. (*M* 1927), Pres., Beasom & Fitch, Inc., 65 Broad St., and (for mail), 51 Brookdale Ave., Rochester, N. Y.

BEATTY, David J. (*M* 1918), 1274 New York Ave., Brooklyn, N. Y.

BEAURRIENNE, Auguste (*M* 1912), 25 Rue des Marguettes, Paris, France.

BEEBE, Frederick E. W. (*A* 1915), Sales Engr. (for mail), Johnson Service Co., Inc., 28 East 29th St., New York, N. Y., and 20 Denman Place, Elizabeth, N. J.

BEERY, Clinton E.* (*M* 1913), Sales Engr. (for mail), Kewanee Boiler Corp., 1858 S. Western Ave., and 4317 N. Paulina St., Chicago, Ill.

BEGGS, William E. (*M* 1927), 3639 Palatine Ave., Seattle, Wash.

BEIGHEL, Howard Atlee (*A* 1927), Sales Repr. (for mail), The Herman Nelson Corp., 320 Penn Ave., Pittsburgh, and 3338 Latonia Ave., Dormont, Pittsburgh, Pa.

BEIRN, John U. (*J* 1928), 210 Voorhees Ave., Buffalo, N. Y.

BELING, Earl H. (*J* 1925), Research Htg. and Vtg. Engr., Herman Nelson Corp., and (for mail), 2428–13th St., Moline, Ill.

BEMAN, Myron C. (*M* 1926), (for mail), Beman & Candee, 607 White Bldg. and 55 Granger Pl., Buffalo, N. Y.

BENDER, Charles P. (*M* 1923), Co-Partner (for mail), C. & J. Bender, 1734 Flatbush Ave., and 2045 East 19th St., Brooklyn, N. Y.

BENEDICT, Everett R. (*M* 1926), Chief of Operations (for mail), United District Htg., Inc., 500 East 102nd St., and 2450 Overlook Rd., Cleveland, O.

BENNETT, George Garman (*M* 1928), 1106 Springfield Ave., Urbana, Ill.

BENNETT, Irving T. (*M* 1928; *A* 1928; *J* 1927), (for mail), Republic Brass Corp., 230 Park Ave., New York, and 234 East 42nd St., Brooklyn, N. Y.

BENNETT, Prescott D. (*M* 1926), 7527 Ridge Blvd., Chicago, Ill.

BENNETT, R. E. (*A* 1928), 838 Judson Ave., Evanston, Ill.

BENNITT, George E. (*M* 1918), Consolidated Gas Co., 130 East 15th St., New York, N. Y.

BENSON, B. A. (*A* 1929), Vulcan Match Co., 25 West 43rd St., New York, and (for mail), Soundview Gardens, Mamaroneck, N. Y.

BENSON, Maurice A. (*J* 1929), Johnson Service Co., 10 E. N. Diamond; N. S. Pittsburgh, Pa.

BENTZ, Harry (*M* 1915), 18 Holland Ter., Montclair, N. J.

BERCHTOLD, Edward W. (*M* 1927; *A* 1925), 29 Randolph St., S. Weymouth, Mass.

BERG, A. Herman (*M* 1919), Pres., Berg Htg. & Vtg. Co., 1310 Ann Ave., St. Louis, Mo., and (for mail), 5317 Abbott Pl., Los Angeles, Calif.

BERGHOEFER, Victor A. (*J* 1926), Secy., Sterling Engrg. Co., 1640 Holton St., and (for mail), 1580 Oakland Ave., Milwaukee, Wis.

BERGNER, William G. (*A* 1923), 616 N. Michigan Ave., Evanston, Ill.

BERMAN, Louis K. (*M* 1908), Vice-Pres. (for mail), Raisler Htg. Co., 129 Amsterdam Ave., and 515 West End Ave., New York, N. Y.

BERMEL, Alfred H. (*J* 1928), 350 N. Sixth St., Newark, N. J.

BERNHARD, George (*A* 1929), Pres-Treas. (for mail), Geo. Bernhard Htg. Co., Inc., 1007 Church Ave., and 417 Ocean Ave., Brooklyn, N. Y.

BERRINGER, Sidney H. (*M* 1926), 1217–50th St., Milwaukee, Wis.

BETTS, Howard M. (*M* 1927), Senior Mech. Engr. (for mail), Dept. of Bldgs., City of Minneapolis, 213 City Hall, and 4923 Russell Ave., S., Minneapolis, Minn.

BETZ, Harry D. (*M* 1928), Chief Air Conditioning Engr., General Refrigeration Co., 1931 Main St., Kansas City, Mo., and (for mail), 4513 Eaton Ave., Kansas City, Kans.

BEVERLY, R. Carter (*M* 1905), Pres. and Treas., R. C. Beverley Htg. Co., Inc., 308 E. Main St., and (for mail), 3812 Chamberlayne Ave., Richmond, Va.

BEVIL, Alexander T. (*J* 1927), Asst. Htg. Engr., Crane Co., 254 Court Ave., and (for mail), 353 Walker Ave., Memphis, Tenn.

BEVINGTON, Warren C. (*M* 1928), Pres., Consulting Engr. (for mail), 1139 Indiana Pythian Bldg., and 327 E. Maple Rd., Indianapolis, Ind.

BEYER, Jack E. (*A* 1927; *J* 1924),. 1317 East 112th St., Cleveland, O.

BIDWELL, R. E. (*A* 1924), Vice-Pres., Gen. Sales Mgr. (for mail), The Kellogg-Mackay Co., 1351 West 37th Pl., Chicago, and 348 Washington Ave., Wilmette, Ill.

BILYEU, William F. (*M* 1927), Eastern Sales Mgr., The Trane Co., 600 S. Delaware Ave., Philadelphia, Pa., and (for mail), 710 Thomas Ave., Riverton, N. J.

BINDER, Charles G. (*M* 1920), Mgr., Htg. Dept., Warren Webster & Co., 17th and Federal Sts., Camden, and (for mail), 115 Oak Ter., Merchantville, N. J.

BINDER, Irving (*M* 1922; *J* 1920), Engr. and Estimator (for mail), Dierks Htg. Co., 210 East 31st St., and 498 West End Ave., New York, N. Y.

BIRCH, Herbert R. (*M* 1922), U. S. Radiator Corp., 101 Park Ave., New York, N. Y.

BIRKHOLZ, H. E. (*A* 1925), Vice-Pres. (for mail), National Air Filter Co., 205 Central Ave., and 2019 Strathmoor Blvd., Louisville, Ky.

BIRRELL, Allan L. (*A* 1925), Equipment Engr. (for mail), Chapman & Oxley, 372 Bay St., and 201 Pacific Ave., Toronto, Ont., Can.

BISHOP, Charles R. (*M* 1901), 413 Locust St., Lockport, N. Y.

BISHOP, Frederick R. (*M* 1921), Mgr., Garland Furnace Div., Detroit-Michigan Stove Co., 6900 E. Jefferson Ave., and (for mail), 4018 Pingree Ave., Detroit, Mich.

BJERKEN, Maurice H. (*A* 1927), Hoffman Specialty Co., 531 South Seventh St., Minneapolis, Minn.

BLACK, Edgar Newbold (*M* 1922), 111 Woodside Rd., Haverford, Pa.

BLACK, F. C. (*M* 1919), Pres. (for mail), F. C. Black Co., 622 W. Randolph St., and 4535 N. Ashland Ave., Chicago, Ill.

BLACK, George E. (*M* 1915), 709 Broad St., Sewickley, Pa.

BLACK, Harry G. (*M* 1917), P. Gormly Co., 155 North Tenth St., Philadelphia, Pa.

BLACK, John J. A. (*A* 1925; *J* 1922), Pres. (for mail), John Black & Sons, Inc., 20 Nassau St., and 3 Harris Rd., Princeton, N. J.

BLACKBURN, Edwin C., Jr. (*M* 1929), 35 Miller Pl., Hempstead, L. I., N. Y.

BLACKHALL, Wilmot R. (*M* 1922), Partner, McKellar & Blackhall, 1104 Bay St., and (for mail), 332 Waverley Rd., Toronto, Ont., Can.

BLACKMAN, Alfred O. (*M* 1911), Consulting Engr. (for mail), 33 West 42nd St., New York, N. Y., and Suburban Club, Stamford, Conn.

BLACKMORE, F. H. (*M* 1923), Mgr., Operating Dept. (for mail), U. S. Radiator Corp., Box 686, and 2322 Tuxedo Ave., Detroit, Mich.

BLACKMORE, George C. (*Charter Member*), Edgewood, Pittsburgh, Pa.

BLACKMORE, J. J. (*Charter Member*), 32 West 40th St., New York, N. Y.

BLACKMORE, Norman L. (*M* 1928), Secy. (for mail), Automatic Gas Steam Radiator Co., 301 Brushton Ave., and 103 Biddle Ave., Pittsburgh, Pa.

BLACKSHAW, Joe L.* (*J* 1929), Research Fellow, Heat Transmission Research, Experimental Engrg. Bldg., University of Minnesota, Minn., and (for mail), 1888 Feronia Ave., St. Paul, Minn.

BLAKE, Albert Henry (*M* 1926), Sheldons, Ltd., 119 Pender St., W., Vancouver, B. C., Can.

BLANDING, George H. (*M* 1919), Salesman, Johnson Service Co., 1355 W. Washington Blvd., Chicago, and (for mail), 800 N. Lombard Ave., Oak Park, Ill.

BLANEY, Charles A. (*M* 1914), Secy. and Gen. Mgr. (for mail), Wheeler-Blaney Co., 249 N. Burdick St., and 301 Douglas Ave., Kalamazoo, Mich.

BLANKIN, Merrill F. (*M* 1927; *A* 1926; *J* 1919), 3328 W. Penn St., Philadelphia, Pa.

BLESSED, William A. (*A* 1929; *J* 1927), Mech. Engr., Smith, Hinchman & Grylls, 800 Marquette Bldg., Detroit, and (for mail), 78 Amherst Rd., Pleasant Ridge, Mich.

BLEST, Frank S. (*M* 1923), Treas. (for mail), Blest & Emery Co., 784 Coney Island Ave., and 226 Argyle Rd., Brooklyn, N. Y.

BLISS, Sherwood C. (*A* 1926), 30 Argonne Dr., Kenmore, N. Y.

BLOMFELDT, Allen A. (*M* 1914), Texo Sales Co., Inc., 241 Walnut St., Cincinnati, O.

BLOOM, Samuel C.* (*M* 1915), Prop. (for mail), S. C. Bloom & Co., 53 W. Jackson St., and 1953 East 72nd St., Chicago, Ill.

BLUME, Frederick J., Jr. (*J* 1929), Sales Engr., American Radiator Co., 40 West 40th St., New York, N. Y., and (for mail), Box 433, Emerson, N. J.

BOALES, William G. (*A* 1923), Asst. Sales Mgr., Hoffman Specialty Co., 1346 Broadway, and (for mail), 1100 Parker Ave., Detroit, Mich.

BOCK, Bernard (*A* 1929; *J* 1927), P. O. Box 96, Times Sq. Sta., 223-241 West 38th St., New York, N. Y.

BODDINGTON, William P. (*M* 1927), The Canadian Power Reg. Co., Ltd., 106 Lombard St., Toronto, Ont., Can.

BOEKER, Carl Herman (*M* 1926), 39 High St., Passaic, N. J.

BOGARDUS, George W. (*M* 1925), Br. Mgr. (for mail), Kewanee Boiler Corp., 606 B. I. Keith Bldg., and 2901 Hampton Rd., Cleveland, O.

BOGARTY, Hermann S. (*M* 1921), 5230 North 15th St., Philadelphia, Pa.

BOISCLAIR, Hugh Cappes (*M* 1926), Warren Webster & Co., Protective Life Bldg., Birmingham, Ala.

BOLLING, Esten (*M* 1921; *J* 1918), Consulting Publicity Engr., Mountain Lakes, N. J.

BOLSINGER, Raymon C. (*M* 1916), Treas. and Sales Mgr. (for mail), Fowler & Wolfe Mfg. Co., Oak and Corson St., Norristown, Pa., and 238 E. Madison Ave., Collingswood, N. J.

BOLTE, Edward E. (*A* 1929), 1502 East 69th Pl., Chicago, Ill.

BOLTON, Reginald Pelham (*Life Member*; *M* 1897), Consulting Engr., Pres. (for mail), The R. P. Bolton Co., Bolton Bldg., 116 East 19th St., and 638 West 158th St., New York, N. Y.

BONDY, Winfield S. (*J* 1926), Htg. & Vtg. Engr., Cass Gilbert, Archt., 244 Madison Ave., and (for mail), 265 West 81st St., Apt. 6 W., New York, N. Y.

BOON, George (*M* 1915), Boon & Sample, Inc., 3008 Ludlow St., Philadelphia, Pa.

BOOTH, C. A. (*M* 1917), Vice-Pres. and Sales Mgr. (for mail), Buffalo Forge Co., 490 Broadway, and 142 Summit Ave., Buffalo, N. Y.

BOOTH, Harry N. (*M* 1924; *A* 1917), U. S. Radiator Corp., 101 Park Ave., New York, N. Y.

BORNEMANN, Walter A. (*M* 1924; *J* 1923), Carrier Engrg. Corp., 2021 Land Title Bldg., Philadelphia, Pa.

BOSTAIN, James C. (*M* 1923), Williamson Heater Co., 337 W. Fifth St., Cincinnati, O.

BOSWIN, George A. (*M* 1917), Vice-Pres. (for mail), R. B. Hayward Co., 1714 Sheffield Ave., and 902 Diversey Pkwy., Chicago, Ill.

BOWERS, Arthur F. (*A* 1919), Pres. (for mail), Industrial Htg. & Engrg. Co., 490 Broadway, and 697 Hackett Ave., Milwaukee, Wis.

BOWERS, J. Sylvan (*M* 1921), Owner (for mail), J. Sylvan Bowers Sales Co., 3805 Page Blvd., and 2525-A W. St. Louis Ave., St. Louis, Mo.

BOWLES, Potter (*A* 1928), Vice-Pres. (for mail), Hoffman Specialty Co., 614 Architects Bldg., Los Angeles, and 1234 El Mirador Dr., Pasadena, Calif.

BOWMAN, Howard A. (*A* 1926), Mgr., Sales Promotion (for mail), American Radiator Co., 310 Second Ave., Pittsburgh, and 2706 Voelkel Ave., Dormont, Pittsburgh, Pa.

BOYD, D. Knickerbocker* (*M* 1921), Consulting Architect (for mail), Structural Service Bureau, 112 South 16th St., Philadelphia, and 8007 Crefeld St., Chestnut Hill, Philadelphia, Pa.

BOYD, William R. (*A* 1926; *J* 1924), Turner Supply Co., 8 W. Sixth St., Chester, Pa.

BOYDEN, Davis S.* (*M* 1909), Edison Elec. Illuminating Co. of Boston, 39 Boylston St., Boston, Mass.

BOYNTON, Daniel Wilcox (*A* 1927), International Heater Co., 77 Franklin St., Boston, Mass.

BOZEMAN, Richard W. (*J* 1929), (for mail), York Htg. & Vtg. Corp., 1541 Sansom St., Philadelphia, and 531 Dudley Ave., Narberth, Pa.

BRABBÉE, Dr. Charles W.* (*M* 1925), American Radiator Co., 675 Bronx River Rd., Yonkers, N. Y.

BRACKEN, John Henry (*M* 1927), Mgr., Special Insulation Dept. (for mail), The Celotex Co., 919 N. Michigan Ave., and 2929 Pine Grove Ave., Chicago, Ill.

BRADFIELD, William W. (*M* 1926), 909 Michigan Trust Bldg., Grand Rapids, Mich.

BRADFORD, H. H. (*A* 1927), 4701 Blaisdell Ave., S., Minneapolis, Minn.

BRADLEY, Eugene P. (*M* 1906), Hester-Bradley Co., 4200 Forest Park Blvd., St. Louis, Mo.

BRADLEY, John T. (*Life Member; M* 1908), (Board of Governors, 1911), Bradley Htg. Co., 3834 Olive St., St. Louis, Mo.

BRADLEY, Royal H. (*M* 1915), Kelsey Htg. Co., 277 James St., Syracuse, N. Y.

BRAEMER, William G. R. (*M* 1915), Niagara Blower Co., La Fayette Bldg., Philadelphia, Pa.

BRANDELES, H. J. (*M* 1921), (for mail), Hudson-Brandeles, Inc., 1600 Lincoln Ave., and 66 Prospect St., Utica, N. Y.

BRANDT, Ernst Hamilton, Jr. (*M* 1928), P. O. Box 292, Charlotte, N. C.

BRANIGAN, Harry L. (*M* 1926), The Air Conditioning & Engrg. Co., 2914 S. Jefferson Ave., St. Louis, Mo.

BRASSINGTON, Arthur F. (*A* 1918), 520-524 West 41st St., New York, and (for mail), 337 Richmond Ave., Port Richmond, N. Y.

BRAUER, Roy (*M* 1926), Chief Engr. (for mail), The Schley Co., Inc., 711 Columbia Bldg., Pittsburgh, and 2880 Glenmore Ave., Dormont, Pa.

BRAUN, Louis T. (*M* 1921), 1418 Jonquil Ter., Chicago, Ill.

BRAYTON, William M. (*M* 1926), Robt. Gordon, Inc., 22 W. Austin Ave., Chicago, Ill.

BRECKENRIDGE, L. P. (*M* 1920), Prof. Emeritus, Mech. Engrg., Yale University, New Haven, Conn., and (for mail), N. Ferrisburg, Vt.

BREEN, Joseph W. (*M* 1916), Htg. Engr., Jos. W. Breen & Sons, Wyalusing Ave. and Fallon St., and (for mail), 957 N. Fallon St., Philadelphia, Pa.

BREITENBACH, George Charles (*J* 1928), Sales Engr. (for mail), The Trane Co., 330 Investment Bldg., and 1431 Chapin St. N. W., Washington, D. C.

BRENEMAN, Robert B. (*J* 1927), Armstrong Cork & Insulating Co., 610 Cahill Bldg., Syracuse, N. Y.

BRESNAHAN, James J. (*M* 1919), Pres. (for mail), James J. Bresnahan, Inc., 41 Pearl St., and 92 Linwood Ave., Buffalo, N. Y.

BREWSTER, Donald R. (*M* 1926), National Lumber Mfrs. Assn., 1339 Bk. of Commerce Bldg., Memphis, Tenn.

BRIDE, W. T. (*M* 1928; *A* 1928; *J* 1925), Bride Grimes & Co., P. O. Box 373, Lawrence, Mass.

BRIDGES, Frank G. (*M* 1919), 13602 McElhattan Ave., College Sta., Cleveland, O.

BRINTON, Joseph W. (*M* 1920), 1003 Statler Bldg., Boston, Mass.

BRODERICK, Joseph F. (*M* 1918; *J* 1914), P. O. Box 388, Springdale, Conn.

BROGAN, James J. (*A* 1917), Senior Partner (for mail), Brogan & Co., 810 Race St., and 6142 Lebanon Ave., Philadelphia, Pa.

BRONSON, Carlos E. (*M* 1919), Mech. Engr. (for mail), Kewanee Boiler Corp., and 311 McKinley Ave., Kewanee, Ill.

BROOKS, Thomas C. (*M* 1923), T. C. Brooks Co., 101 W. Dedham St., Boston, Mass.

BROOM, Benjamin Alexander (*M* 1914), Sales Promotion Engr. (for mail), Weil-McLain Co., 641 W. Lake St., and 7440 Malvern Ave., Chicago, Ill.

BROWN, Alfred P. (*M* 1927), Pres., Alfred P. Brown, Inc., Seattle, Wash., and (for mail), 618 Willow Rd., Winnetka, Ill.

BROWN, Aubrey I. (*M* 1923), Associate Prof. of Htg. and Vtg. (for mail), Ohio State University, and 169 Richards Rd., Columbus, O.

BROWN, Chet (*A* 1928), Pres. (for mail), The Brown Co., 1055 W. Baltimore Ave., and 1053 W. Baltimore Ave., Detroit, Mich.

BROWN, Foskett* (*M* 1926), Vice-Pres. (for mail), Gray & Dudley Co., 222 Third Ave. N., and 2314 West End Ave., Nashville, Tenn.

BROWN, John H. (*M* 1920), Keasbey & Mattison Co., 429 N. Washington Ave., Minneapolis, Minn.

BROWN, Morris (*J* 1928), 609 W. Park St., Dorchester, Mass.

BROWN, Robert H. (*M* 1926), 1102 Old South Bldg., Boston, Mass.

BROWN, William H. (*A* 1923), 1227-22nd St., Milwaukee, Wis.

BROWNE, Alfred L. (*M* 1923), Illinois Engrg. Co., 3514 Grand Central Terminal, New York, N. Y.

BROWNING, H. K. (*J* 1926), Dist. Sales Repr. (for mail), A. M. Byers Co., 415 Shell Bldg., and 6059 Cates Ave., St. Louis, Mo.

BRUEGGEMAN, Arthur R. (*M* 1920), The A. R. Brueggeman Co., 1212 Terminal Tower, Cleveland, O.

BRUNETT, Adrian L. (*M* 1923), Associate Mech. Engr., U. S. Supervising Architect Office, U. S. Treasury Bldg., Washington, D. C., and (for mail), P. O. Box 16, Rockville, Md.

BRUNT, T. Bayard (*M* 1917), 405 Eighth St., Riverton, N. J.

BRYANT, Dr. Alice G. (*M* 1921), 502 Beacon St., Boston, Mass.

BRYANT, Percy J. (*M* 1915), Chief Engr. (for mail), Prudential Insurance Co., Newark, and 530 Hanford Pl., Westfield, N. J.

BRYCE, Stephen D. (*M* 1921), Partner (for mail), Bryce Htg. & Vtg. Co., 2014-16 North 14th St., and 2907 Rockwood Pl., Toledo, O.

BUCK, Lucien (*M* 1928), Buck Dryer Corp., 122 East 42nd St., New York, N. Y.

BUDER, Charles G.* (*M* 1919), Pres. (for mail), Boiler Service Corp., 1415 Pine St., St. Louis, and 2000 Urban Ave., Forest Hills Park, Webster Groves, Mo.

BUEL, H. G. (*A* 1921), Vice-Pres. (for mail), Tilghman Moyer Co., 141 N. Ninth St., and 2135 Chew St., Allentown, Pa.

BUENGER, Albert* (*M* 1920; *J* 1917), Mech. Engr., C. H. Johnson, Architect, 360 Robert St., and 1666 Stanford Ave., St. Paul, Minn.

BUENSOD, Alfred Charles (*M* 1918), Sales Engr., Carrier Engrg. Corp., 39 Cortlandt St., and (for mail), 1 Fifth Ave., New York, N. Y.

BULKELEY, Claude A.* (*M* 1923), Chief Engr. (for mail), Niagara Blower Co., 673 Ontario St., and 84 W. Hazeltine Ave., Kenmore Sta., Buffalo, N. Y.

BUNNELL, E. W. (*M* 1924; *J* 1923), Sales Engr., Bozeman, Mont.

BURKE, Fletcher H. (*M* 1925), Professional Engr. (for mail), 677 Ellicott Sq., Buffalo, and Orchard Park, N. Y.

BURKE, George B. (*M* 1926), Vice-Pres. (for mail), Sarco Co., Inc., 205 W. Wacker Dr., Chicago, and 611 Ninth St., Wilmette, Ill.

BURNAP, Charles W. (*M* 1922), Herman Nelson Corp., 724 Commercial St., Emporia, Kans.

BURNETT, Earle S. (*M* 1920), Mech. Engr., U. S. Helium Production Plant, Box 2025, and (for mail), 4223 West 11th Ave., Amarillo, Tex.

BURNS, Edward J. (*M* 1923), Supt. (for mail), H. Kelly & Co., 925 Phymonth Bldg., and 4716 Aldrich Ave., S., Minneapolis, Minn.

BURNS, Willard A. (*M* 1924), (for mail), Burns Htg. Co., 4230 Lincoln Ave., and 1728 Farwell Ave., Chicago, Ill.

BURRITT, Charles G. (*A* 1916), Johnson Service Co., 922 Second Ave. S., Minneapolis, Minn.

BURT, John E. (*M* 1924), J. B. Burt & Son, 2442 South 16th St., Philadelphia, Pa.

BURTON, C. A. (*M* 1919), Br. Mgr. (for mail), Kewanee Boiler Corp., 2020 Wyandotte St., Kansas City, Mo.

BUSHNELL, Carl D. (*A* 1921), Bushnell Machinery Co., 1501 Grant Bldg., Pittsburgh, Pa.

BUTLER, C. W. (*M* 1929; *A* 1929; *J* 1927), Sales Engr. (for mail), American Blower Corp., 1221 Boatmens Bk. Bldg., and 5707 McPherson, St. Louis, Mo.

BUTLER, Peter D. (*M* 1922), 127 Edgewater Ave., Grantwood, N. J.

C

CADWELL, William H. (*M* 1916), Pres. (for mail), The Beaton & Cadwell Mfg. Co., P. O. Box 1012, and 130 W. Main St., New Britain, Conn.

CALAHAN, John (*M* 1915), Supervising Engr. (for mail), Board of Education, 2 Harrison Ave., and 79 Bartholdi Ave., Jersey City, N. J.

CALEB, David (*M* 1923), Engr. (for mail), Kansas City Power & Light Co., 1330 Grand Ave., and 141 Spruce St., Kansas City, Mo.

CALLAGHAN, Philip F., Jr. (*J* 1929), Sales Engr. (for mail), Rome Brass Radiator Corp., 333 N. Michigan Ave., and 1554 Juneway Ter., Chicago, Ill.

CALLAHAN, Michael J. (*M* 1914), 776 Union Ave., Bridgeport, Conn.

CALLAHAN, Thomas H. (*M* 1928; *A* 1928; *J* 1924), Callahan Engrg. Co., 20 Grove St., White Plains, N. Y.

CALLON, Harry, Jr. (*A* 1928), Office Mgr. (for mail), Callon Bros., 24 S. Alabama St., and 3001 East 38th St., Indianapolis, Ind.

CALVERT, Norman W.* (*M* 1921), 2651 W. Harrison St., Chicago, Ill.

CAMPBELL, Everett K.* (*M* 1920), Pres. and Treas. (for mail), E. K. Campbell Htg. Co., 2441-3-5 Charlotte St., and 3717 Harrison Blvd., Kansas City, Mo.

CAMPBELL, F. B. (*A* 1927), Own Business (for mail), Barclay-Campbell Co., 10 Murray St., New York, and 1205-A Bergen St., Brooklyn, N. Y.

CAMPBELL, J. Packard (*A* 1928; *J* 1927), Engr., The James Robertson Co., Ltd., P. O. Box 1000, St. John, and (for mail), Manawagonish Rd., Fairville, N. B., Can.

CAMPBELL, John M. (*A* 1919), R 2 Plymouth, Plymouth, Mich.

CAMPBELL, Thomas F. (*M* 1928), Distributor (for mail), Minneapolis-Honeywell Regulator Co., 1013 Penn Ave., Wilkinsburg, and 580 Oakwood St., Pittsburgh, Pa.

CAREY, James A. (*M* 1928), Gen. Sales Mgr. (for mail), York Htg. & Vtg. Corp., 1541 Sansom St., Philadelphia, and Wynnewood, Pa.

CARLE, William E. (*M* 1926), Carle-Boehling Co., 1641 W. Broad St., Richmond, Va.

CARLSON, Everett E. (*A* 1929), Br. Mgr. (for mail), The Powers Regulator Co., 1010 Louderman Bldg., and 6652 Washington Ave., St. Louis, Mo.

CARMAN, G. G. (*J* 1928), Pres. and Chief Engr. (for mail), Dykema, Carman & Dykema, Inc., 802 Grand Rapids Trust Bldg., and 900 Giddings Ave. S. E., Grand Rapids, Mich.

CARNAHAN, Glen C. (*M* 1924), 5428 Woodlawn Ave., Chicago, Ill.

CARPENTER, R. H. (*M* 1921), Mgr., New York Office (for mail), Nash Engrg. Co., Graybar Bldg., 420 Lexington Ave., New York, and 10 Jefferson Ave., White Plains, N. Y.

CARR, Clifford H. (*A* 1924), Pres. and Mgr. (for mail), C. H. Carr & Co., 411 Mutual Bldg., and 5108 Main St., Kansas City, Mo.

CARRASCO, Saturnino (*J* 1928), Monedo 944, Santiago, Chile, S. A.

CARRIER, Willis H. (*M* 1913), (2nd Vice-Pres., 1929; Council, 1923-1929), Pres. (for mail), Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, and Rensselaer Rd., Essex Fells, N. J.

CARROLL, W. J. (*A* 1925), Kewanee Boiler Corp., 402½ Michigan Trust Bldg., and (for mail), 339 Burton St. S. E., Grand Rapids, Mich.

CARSTEN, W. H. (*M* 1923), Majestic Furnace & Mfg. Co., 1723 Westlake Ave. N., Seattle, Wash.

CARSTENS, Emil (*A* 1925; *J* 1922), Sales Engr., H. B. Smith Co., 2209 Chestnut St., and (for mail), 4615 Rosehill St., Philadelphia, Pa.

CASEY, Byron L. (*M* 1921), Ilg Elec. Vtg. Co., 324 W. Monroe St., Chicago, Ill.

CASH, Tidie T. (*A* 1925), Grinnell Co., 240 Seventh Ave. S., Minneapolis, Minn.

CASSELL, John D.* (*M* 1913), Board of Public Education, 19th and Chestnut Sts., Philadelphia, Pa.

CASSERLY, T. D. (*A* 1923), 5339 Winthrop Ave., Chicago, Ill.

CASTIN, Laurence N. (*M* 1927), 1212 Michigan Ave., Buffalo, N. Y.

CATLIN, Byron J. (*A* 1929), Asst. Htg. Engr. (for mail), New Haven Gas Light Co., and 33 Lake Pl., New Haven, Conn.

CAVILEER, James V. (*A* 1921), York Htg. & Vtg. Corp., 1541 Sansom St., Philadelphia, Pa.

CHADWICK, John B. (*M* 1926), 11 Orville Dr., Burnage Hall Rd., Burnage, Manchester, Eng.

CHALLMAN, Samuel A. (*M* 1919), Director of School Bldgs., State Dept. of Education, State Capitol, St. Paul, Minn.

CHAMBERS, W. E. (*A* 1923), Htg. Contractor, 1025 Franklin St., Williamsport, Pa.

CHAPMAN, D. Witt (*M* 1914), 427 Bond Bldg., Washington, D. C.

CHAPMAN, Frank T. (*M* 1909), (1st Vice-Pres., 1916; 2nd Vice-Pres., 1915; Council, 1913-1916), 2539 Durant Ave., Berkeley, Calif.

CHAPPELL, Robert E. (*M* 1928), Repr. (for mail), Magnolia Gas Co., Magnolia Bldg., and Mayfair Hotel, Dallas, Tex.

CHAPPELL, Temple A. (*M* 1926), Owner of Business, P. O. Box 143, Weldon, N. C.

CHASE, John M. (*A* 1916), 50 East 42nd St., New York, N. Y.

CHENOWETH, William H. (*M* 1911), Chicago Dist. Mgr. (for mail), Warren Webster & Co., 549 W. Washington St., Chicago, and 541 Keystone Ave., River Forest, Ill.

CHERRY, Lester A. (*M* 1921), Industrial Planning Corp., 45 Court St., Buffalo, N. Y.

CHERVEN, Victor W. (*M* 1928; *A* 1920), Holland Furnace Co., Holland, Mich.

CHESTER, Thomas (*M* 1917), 1318 Cordova Rd., Pittsburgh, Pa.

CHEYNEY, Charles C. (*A* 1925), Buffalo Forge Co., 490 Broadway, Buffalo, N. Y.

CHILDRESS, Worthie Lee (*M* 1925), 609 West 27th St., Richmond, Va.

CHOFFIN, C. C. (*M* 1919), W. J. Scholl & Co., Mahoning Ave. and Hogue St., Youngstown, O.

CHRISTIAN, Charles W. (*M* 1913), P. O. Box 292, 935 Providence Rd., Charlotte, N. C.

CHURCH, Herbert John (*M* 1922), Darling Bros., Ltd., 77 York St., Toronto, Ont., Can.

CLAFFEY, Edward J. (*M* 1913), 10 W. Illinois St., Chicago, Ill.

CLARE, Fulton Warren (*M* 1927), Prop. (for mail), Clare & Co., 611 Bona Allen Bldg., and 1316 North Ave. N. E., Atlanta, Ga.

CLARK, E. Harold (*M* 1922), Br. Mgr., J. D. Swartwout Co., 606 Michigan Theater Bldg., and (for mail), 132 Pingree St., Detroit, Mich.

CLARK, Homer J. (*M* 1919), Mgr., Htg. & Vtg. Dept., B. F. Sturtevant Co., 1042 Wrigley Bldg., Chicago, Ill.

CLARK, W. H. (*M* 1921), 932 Berkshire Ave., South Hills Br., Pittsburgh, Pa.

CLARKE, Samuel S. (*M* 1909), Pres. and Mgr. (for mail), S. S. Clarke & Co., Ltd., 605 Second St. W., and 603 Second St. W., Calgary, Alberta, Can.

CLARKSON, Robert C., Jr. (*M* 1921), 821 South 49th St., Philadelphia, Pa.

CLARKSON, W. B. (*M* 1919), Vice-Pres., King Vtg. Co., and (for mail), 251 Broadway, Owatonna, Minn.

CLEGG, Carl (*M* 1922), American Blower Co., 311 Mutual Bldg., Kansas City, Mo.

CLELAND, James E. (*M* 1925), Pres. (for mail), Cleland Engrg. Co., 208 Fifth St., and 73 N. Princeton St., Lynchburg, Va.

CLEMENT, E. R. (*A* 1924), 77 Richardson St., Bridgeport, Conn.

CLIFTON, William F. (*M* 1923), W. F. Clifton & Co., 313 Brock Ave., Toronto, Ont., Can.

CLOSE, Paul D.* (*M* 1928), Tech. Secy. (for mail), American Society Htg. & Vtg. Engrs., 29 West 39th St., New York, and 294 Bronxville Rd., Bronxville, N. Y.

CLOUGH, Leslie (*M* 1922), 203 Pierce Rd., Weymouth, Mass.

CLOW, Milton T. (*J* 1926), James B. Clow & Sons, 201 N. Talman Ave., Chicago, Ill.

CLUCAS; W. Frank (*M* 1928), 483 Elmwood Ave., Buffalo, N. Y.

COE, Ivan B. (*M* 1918), Pres. and Treas. (for mail), Blower Systems Corp., 362 Plymouth Ave. S., and 122 Penhurst St., Rochester, N. Y.

COE, Ralph T. (*M* 1917), Senior Partner (for mail), The R. T. Coe Cos., 907 Gas and Elec. Bldg., and 235 Chili Ave., Rochester, N. Y.

COHAGEN, Chandler C. (*M* 1919), Architect (for mail), McIver & Cohagen, Hedden Bldg., Box 1305, and 127 Wyoming Ave., Billings, Mont.

COLBY, Clyde W. (*M* 1915), 2341 Carnegie Ave., Cleveland, O.

COLE, Grant E. (*A* 1925), Vice-Pres., Trane Co. of Can., Ltd., 439 King St., W. Toronto, and (for mail), 128 Grenadier Rd., Toronto, Ont., Can.

COLEMAN, John B. (*M* 1920), Grinnell Co., Inc., 260 W. Exchange St., Providence, R. I.

COLLAMORE, Ralph (*M* 1904), (Board of Governors, 1913), Secy., Smith, Hinchman & Grylls, 800 Marquette Bldg., and (for mail), 679 Pingree Ave., Detroit, Mich.

COLLETTE, John R. (*A* 1928), Pacific Steel Boiler Corp. of Ill., Waukegan, Ill.

COLLIER, William I. (*M* 1921), W. I. Collier & Co., 522 Park Ave., Baltimore, Md.

COLLVER, Gordon L. (*J* 1927), 63 Beattie Ave., London, Ont., Can.

COMSTOCK, Glen Moore (*A* 1926), Chief Engr. (for mail), Rush Machinery Co., 32 E. Carson St. S., S. Pittsburgh, and 154 College Ave., Beaver, Pa.

CONNELL, Richard F. (*M* 1916), Mgr., Capitol Testing Lab. (for mail), U. S. Radiator Corp., 127 Campbell Ave., and 2970 Burlingame Ave., Detroit, Mich.

COOK, Benjamin F. (*M* 1920), Consulting Engr., 713 Linwood Blvd., Kansas City, and (for mail), 1720 Overton Ave., Independence, Mo.

COOK, Chester D. (*M* 1921), 2340-42 Pine St., St. Louis, Mo.

COOK, Harris R. (*A* 1924), American Foundry & Furnace Co., Room 400, 15 Michigan St., Milwaukee, Wis.

COON, Thurlow E. (*M* 1916), 826 Edison Ave., Detroit, Mich.

COOPER, Albert W. (*A* 1925), Br. Mgr. (for mail), Johnson Service Co., 610 McIntyre Bldg., and 2543 Highland Dr., Salt Lake City, Utah.

COOPER, Frank Irving* (*M* 1911), (Council, 1914-1916), Pres., Frank Irving Cooper Corp., 172 Tremont St., Boston, Mass.

COOPER, Harry (*A* 1924), H. Cooper Supply Co., 223 Water St., Springfield, Mo.

COOPER, John W. (*A* 1925), Buffalo Forge Co., 906 Chemical Bldg., St. Louis, Mo.

COOPER, Thomas R. (*M* 1923), 13 Park St., Winterton near Scunthorpe, Lincolnshire, Eng.

COOPER, Thomas W. (*A* 1922), Sales Engr., Haynes Selling Co., 2013 Sansom St., and (for mail), 5117 N. Mervine St., Philadelphia, Pa.

CORBIN, William E. (*J* 1929), 445 W. Larned, Detroit, Mich.

CORNELL, Harold (*A* 1925), Davies Supply Co., 6601 Grand Ave., Chicago, Ill.

CORNWALL, George T. (*M* 1919), Mgr., Boiler Dept. (for mail), Hitchings & Co., 701 Spring St., and 633 Madison Ave., Elizabeth, N. J.

COSGROVE, Wallace M. (*M* 1923), Vice-Pres. (for mail), American Radiator Co., 40 West 40th St., New York, N. Y., and 240 Ridgewood Rd., S. Orange, N. J.

COTTON, Roland M. (*A* 1928), Secy-Treas. (for mail), Roland M. Cotton Co., 1720-26 E. Tenth St., and R. R. 11., Box 27-B, Indianapolis, Ind.

COUGHLIN, R. J. (*M* 1925), 8215 Maryland Ave., Chicago, Ill.

COUSENS, Walter S. (*M* 1924), 46 Shornecliff Rd., Newton, Mass.

COWARD, Herbert (*M* 1921), Repr. (for mail), Buffalo Forge Co., 418 Washington Loan & Trust Bldg., Washington, D. C., and Falls Church, Va.

COWLES, Benjamin E. (*M* 1919), Kellogg-Mackay Co., 824 S. Fourth St., Minneapolis, Minn.

COX, Christopher J. (*M* 1919), C. J. Cox Engrg. Co., 625 Putnam Ave., Cambridge, Mass.

COX, William F. (*M* 1924), Crane Co., 1532 Grand Ave., Kansas City, Mo.

COX, William W. (*M* 1923), Htg. Service Co., 326 Columbia St., Seattle, Wash.

CRAWFORD, William Blake (*M* 1921), Distributor of Htg. Specialties, 228 N. La Salle St., and (for mail), 1516 N. Mayfield Ave., Chicago, Ill.

CRIQUI, Albert A.* (*M* 1919), Chief Engr., Htg. & Vtg. Dept., Buffalo Forge Co., 490 Broadway, and (for mail), 250 Blaine Ave., Buffalo, N. Y.

CROFT, Terrell (*M* 1924), Airport Engr., Pan-American Airways, Miami, Fla.

CRONE, Charles E., Jr. (*M* 1922), Secy-Treas. (for mail), Wendt & Crone Co., 1131 N. Wells St., and 1320 N. State St., Chicago, Ill.

CRONE, Thomas E. (*M* 1920), Dist. Mgr., Rome Brass Radiator Corp., 1 East 42nd St., and (for mail), 235 West 71st St., New York, N. Y.

CRUTCHLEY, Edward, Jr. (*M* 1920), Htg. Engr. and Contractor (for mail), 477-83rd St., and 78 89th St., Brooklyn, N. Y.

CULBERT, Warren G. (*A* 1911), Pres., Culbert-Whitby Co., Inc., 2019 Rittenhouse St., Philadelphia, and (for mail), 38 Chester Pike, Ridley, Pa.

CULBERT, William P. (*A* 1929), 2019 Rittenhouse St., Philadelphia, Pa.

CUMMING, Robert W. (*M* 1928), Mech. and Sales Engr. (for mail), Sarco Co., Inc., 183 Madison Ave., New York, and 81 Alkamont Ave., Scarsdale, N. Y.

CUMMINGS, Carl H. (*A* 1927; *J* 1926), Mgr. (for mail), Industrial Appliance Co. of New England, 250 Stuart St., and 41 Edgehill Rd., Chestnut Hill, Mass.

CUMMINGS, Charles A. (*M* 1929; *A* 1929; *J* 1926), Capitol Testing Lab. (for mail), U. S. Radiator Corp., 127 Campbell Ave., and 844 Delaware Ave., Detroit, Mich.

CUMMINGS, G. J. (*M* 1923), Htg. Supt., The Scott Co., 113 Tenth St., and (for mail), 2001 Hoover Ave., Oakland, Calif.

CUMMINS, George H. (*M* 1919), Dist. Repr. (for mail), Aerofin Corp., 418 United Artists Bldg., and 17193 Roselawn Ave., Detroit, Mich.

CUNNINGHAM, Noel (*M* 1929), Domestic Stoker Co., 7 Dey St., New York, N. Y.

CURRIER, Charles H. (*M* 1919), Vice-Pres. and Gen. Mgr. (for mail), Drying Systems, Inc., 1800 Foster Ave., and 2440 Lake View Ave., Apt. 9-D, Chicago, Ill.

CUTLER, Joseph A. (*M* 1916), (Council, 1917-1926), Mgr. (for mail), Johnson Service Co., 1355 Washington Blvd., Chicago, and 649 Hinman Ave., Evanston, Ill.

CUTTER, Edward H. (*A* 1923), (for mail), 179 W. Washington St., Chicago, and 912 Douglas Ave., Elgin, Ill.

D

DAHLSTROM, Godfrey A. (*A* 1927), Dept. Mgr., Roberts-Hamilton Co., 713 So. Third Ave. S., and (for mail), 2412-28th Ave. S., Minneapolis, Minn.

DAILEY, James A. (*A* 1920), 304 West 14th St., New York, N. Y.

DAILEY, James F. (*M* 1924), Pres. and Chief Engr., Typhoon Fan Co., 345 West 39th St., New York, and (for mail), 25 Wilson Dr., New Rochelle, N. Y.

DALY, John H. (*M* 1915), 1635 Blake St., Denver, Colo.

DAMBLY, A. Ernest (*M* 1924; *J* 1921), Asst. Consulting Engr. (for mail), 1001 Ledger Bldg., and 243 W. Tulpehocken St., Philadelphia, Pa.

DANE, Irving S. (*M* 1925), 166 George St., Medford, Mass.

DANFORTH, Newman L. (*M* 1919), John W. Danforth Co., 72 Ellicott St., Buffalo, N. Y.

DANNIES, F. R. (*A* 1925), Mgr., National Radiator Corp., 2003-9 St. Paul Ave., Milwaukee, and (for mail), 465 Fourth Ave., Wauwatosa, Wis.

DARLING, Arthur B. (*A* 1929), Mgr. of Webster Systems (for mail), Darling Bros., Ltd., 140 Prince St., and 1935 St. Luke St., Montreal, P. Q., Can.

DARTON, Arthur W. (*A* 1925), 314 Fulton St., Union Hill, Union City, N. J.

DARTS, John A. (*M* 1919), Kewanee Boiler Co., Inc., 570 Seventh Ave., New York, N. Y.

DAUCH, Emil O. (*M* 1921), 81 Montana Ave. W., Detroit, Mich.

DAVIDSON, L. Clifford (*M* 1927), Associate Dist. Mgr. (for mail), Buffalo Forge Co., 810 Land Title Bldg., and 916 South 49th St., Philadelphia, Pa.

DAVIDSON, Phillip L. (*M* 1924; *J* 1921), Dist. Sales Mgr. (for mail), Carrier Engrg. Corp., 1724 Land Title Bldg., Philadelphia, and Haverford Gables, Haverford, Pa.

DAVIDSON, Ralph A. (*J* 1928), 233 Summer St., Stamford, Conn.

DAVIES, George W. (*M* 1918), G. W. Davies & Co., 79 McLaggan St., Dunedin, New Zealand.

DAVIS, Arthur C. (*M* 1920), Asst. Supt., The Holland Tunnel, Canal and Varick Sts., New York, N. Y., and (for mail), 73 Preston St., Ridgefield Park, N. J.

DAVIS, Bert C. (*M* 1904), Pres. and Treas. (for mail), American Warming & Vtg. Co., 317-319 Pennsylvania Ave., and 603 W. Church St., Elmira, N. Y.

DAVIS, Calvin R. (*M* 1927), Mgr. of St. Louis Office (for mail), Johnson Service Co., 2328 Locust St., and 7534 Westmoreland Ave., St. Louis, Mo.

DAVIS, Herbert H. (*A* 1929), Secy-Treas. (for mail), Herbert H. Davis Co., 4146 S. Western Ave., and 6229 S. Sacramento Ave., Chicago, Ill.

DAVIS, James H. (*Charter Member*), (Board of Governors, 1911), Bryson Hotel, 4932 Lake Park Ave., Chicago, Ill.

DAVIS, Joseph (*M* 1927; *A* 1926), 72 W. Northrop Pl., Buffalo, N. Y.

DAVIS, Leo J. (*M* 1917), 18261 Grayfield Ave., Detroit, Mich.

DAVIS, Otis E. (*M* 1929; *A* 1925), 1523 First Ave., Scotts Bluff, Nebr.

DAVIS, Rowland G. (*A* 1921), Sales Engr., Herbert Nelson Corp., 1900 Euclid Ave., Cleveland, and (for mail), 887 Nela View Rd., Cleveland Heights, O.

DAY, V. S.* (*M* 1924), Chief Engr. (for mail), Carrier-Lyle Corp., 850 Frelinghuysen Ave., Newark, and 357 Lincoln Ave., Orange, N. J.

DECKER, Edward M. (*A* 1917), Salesman (for mail), American Radiator Co., 1344 Broadway, Detroit, Mich.

DEEX, Charles J. (*M* 1920), Pres. (for mail), The Mouat Vapor Htg. Co., 1246 W. Fourth St., and 4364 Rock River Dr., Cleveland, O.

DEGAN, James E. (*A* 1916), Owner (for mail), James E. Degan Co., 2130 Franklin St., and 2428 Blaine Ave., Detroit, Mich.

DEGNAN, Thomas J. (*A* 1929), American Radiator Co., 304 North 2nd St., Harrisburg, Pa.

DeHAVEN, I. C. (*A* 1928), I. C. DeHaven Engrg. Co., 708 State Life Bldg., Indianapolis, Ind.

DELAND, Charles W. (*M* 1924; *J* 1923), C. W. Johnson, Inc., 211 N. Desplaines St., Chicago, Ill.

DeLONG, Maj. Harry B. (*M* 1915), Owner (for mail), The H. B. DeLong Co., 219 Riverside Ave., and East 231–24th Ave., Spokane, Wash.

DEMPSEY, Harry P. (*M* 1919), 34 Delaware Court, 232 Delaware Ave., Buffalo, N. Y.

DeNEILLE, J. Lawrence (*M* 1920), Secy-Treas. (for mail), Eichler Htg. Co., 2010 Railway Exchange Bldg., and 7227 Maryland Ave., St. Louis, Mo.

DENHOLM, John A., Jr. (*J* 1929), Junior Engr., Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, N. J., and (for mail), 23 Sagamore Rd., Bronxville, N. Y.

DENNIS, C. K. (*A* 1926; *J* 1923), Standard Heaters, 309 O. C. S. Bk. Bldg., Syracuse, N. Y.

DENSON, Walter (*M* 1922), 2916 Olga Pl., Jacksonville, Fla.

DePALMA, James Robert (*J* 1928), 9134–87th St., Woodhaven, N. Y.

DERANLEAU, Raymond L. (*M* 1924; *J* 1922), Htg. and Vtg. Engr., National Distributors, Inc., and (for mail), 1930 Jasimine St., Denver, Colo.

DEVENDORF, William F. (*M* 1910), Prop. (for mail), Wm. F. Devendorf & Co., 70 Exchange St., and 737 East Ave., Rochester, N. Y.

DeWOLF, Roger D. (*M* 1915), Asst. Supt., Electric Dept. (for mail), Rochester Gas & Elec. Corp., 89 East Ave., and 330 Barrington St., Rochester, N. Y.

DEXTER, Mac D. (*M* 1924), Dexter Ventilator Co., Columbus, Ga.

DIBBLE, Samuel Edward* (*M* 1917), (*Presidential Member*), (Pres., 1925; 1st Vice-Pres., 1924; 2nd Vice-Pres., 1922; Council, 1921-1926), Prof. of Htg. and Vtg. (for mail), Carnegie Institute of Technology, Schenley Park, Pittsburgh, and 514 Hastings St., Pittsburgh, Pa.

DICKEY, Arthur J. (*M* 1921), Vice-Pres. and Gen. Mgr., C. A. Dunham Co., Ltd., 1523-41 Davenport Rd., and (for mail), 9 Mossom Pl., Toronto, Ont., Can.

DICKINSON, Charles E. (*M* 1926), Dickinson Htg. Co., 2814 West 55th St., Chicago, Ill.

DICKSON, Robert B. (*M* 1919), Vice-Pres., in Charge of Sales (for mail), Kewanee Boiler Corp., and 409 E. Prospect St., Kewanee, Ill.

DIGBY, Homer E. (*A* 1925; *J* 1922), Salesman, Dwyer Equipment Co., 3002 Grant Bldg., and (for mail), 216 Oneida St., Pittsburgh, Pa.

DILL, Harry O. (*A* 1922), 525 East 29th St., Brooklyn, N. Y.

DILLMAN, Ernest J. (*M* 1921), American Radiator Co., 5961 Lincoln Ave., Detroit, Mich.

DILLON, H. R. (*A* 1923), Dist. Sales Mgr. (for mail), National Radiator Corp., 55 West 42nd St., New York, and 81 Palmer Ave., Larchmont, N. Y.

DINGLEMAN, Charles S. (*M* 1929), Consulting Engr. (for mail), 1132 Fidelity Philadelphia Trust Bldg., Philadelphia, and Drexel Park, Pa.

DISTEL, Frank (*M* 1918), Owner (for mail), Distel Htg. Equipment Co., 125 E. Shiawassee St., and 1011 W. Genesee St., Lansing, Mich.

DIVER, M. L. (*M* 1925), Consulting Engr., P. O. Box 1073, San Antonio, Tex.

DIX, Harry Morton (*M* 1925), Htg. Engr., American Radiator Co., 38 Fountain St., Providence, R. I., and (for mail), 11 Elmwood St., Worcester, Mass.

DIXON, Arthur G. (*M* 1928), Western Sales Mgr., Modine Mfg. Co., and (for mail), 1046 College Ave., Racine, Wis.

DOBBS, C. E. (*A* 1921), 72 Berlin Ave., Haddonfield, N. J.

DOBSON, George Gardner (*M* 1922), 166 Harding Rd., Rochester, N. Y.

DODDS, Forrest F. (*M* 1920), Mgr. (for mail), American Radiator Co., 1423 Baltimore Ave., and Ambassador Hotel, Kansas City, Mo.

DOERING, Frank L. (*M* 1919), Sales Repr., American Radiator Co., 219 Denver Ave., Lynchburg, Va.

DOHERTY, John A. (*M* 1924), Engr., Richardson & Boynton Co., 260 Fifth Ave., New York, and (for mail), 1834 Schenectady Ave., Brooklyn, N. Y.

DOHERTY, John J. (*M* 1921), P. C. Doherty Co., 114 Main St., Poughkeepsie, N. Y.

DOHERTY, Russell (*A* 1929), Asst. Br. Mgr. (for mail), National Radiator Corp., 2445 N. Keeler Ave., Chicago, and 302 N. Oak Park Ave., Oak Park, Ill.

DOLAN, Edward M. (*A* 1927), Editorial Dir. (for mail), Sanitary Age, Ltd., 31 Willcocks St., and 10 Ladykirk Ave., Toronto, Ont., Can.

DOLAN, Raymond G. (*M* 1926; *A* 1926; *J* 1922), Secy-Treas. (for mail), Tom Dolan Htg. Co., Inc., 614-616 W. Grand Ave., and 2112 West 20, Oklahoma City, Okla.

DOLAN, William H., Jr. (*J* 1927), Asst. Treas. (for mail), The Jennison Co., and 65 Linden St., Fitchburg, Mass.

DOME, Walter R. (*M* 1920), 7129 Chew St., Philadelphia, Pa.

DONNELLY, James A.* (*M* 1904), (Treas., 1912-1914), Largent, W. Va.

DONNELLY, Russell (*M* 1923), Nash Engrg. Co., Inc., Graybar Bldg., 420 Lexington Ave., New York, N. Y.

DONNELLY, Webster C. (*A* 1929; *J* 1922), River Bank Court Hotel, Cambridge, Mass.

DONOGHUE, James J. (*A* 1924), National Radiator Co., 55 West 42nd St., New York, N. Y.

DONOHUE, Edmund S. (*A* 1924), American Radiator Co., 1344 Broadway, Detroit, Mich.

DONOVAN, James E. (*A* 1922; *J* 1923), 618 Forest Ave., Rye, N. Y.

DOODY, Catherine A. (*M* 1924), Silent Automatic Corp., 255 Meldrum Ave., Detroit, Mich.

DORFAN, M. I. (*M* 1929), Mgr., Dust Collecting Div. (for mail), Pangborn Corp., Box 85, and 921 Oak Hill Ave., Hagerstown, Md.

DORNHEIM, G. A. (*M* 1912; *J* 1906), Thompson-Starrett Co., 245 Hunters Point Ave., Long Island City, N. Y.

DORSEY, Francis C. (*M* 1920), 110 Prospect Ave., Roland Park, Baltimore, Md.

DOUGHERTY, P. J.* (*M* 1926), 208 E. Lomita Ave., Glendale, Calif.

DOUGHTY, Charles John (*M* 1925), Pres. and Managing Dir., C. J. Doughty & Co., 30 Brenan Rd., Shanghai, China.

DOUGLASS, Thomas C. (*M* 1922), 1416 Alvarado Ave., Burlingame, Calif.

DOWNE, Edward R. (*M* 1927), Dir., Gas Utilization Dept. (for mail), American Radiator Co., 40 West 40th St., and 31 Howell Ave., Larchmont, N. Y.

DOWNE, Henry S. (*M* 1895), American Radiator Co., 149 Blvd. Haussman, Paris, France.

DOWNES, Nate W. (*M* 1917), (Council, 1928-1929), Chief Engr. and Supt. of Bldgs. (for mail), School District of Kansas City, Mo., 601 Finance Bldg., and 2119 East 68th St., Kansas City, Mo.

DOWNEY, Paul C. (*M* 1928; *A* 1928; *J* 1926), Downey Htg. Co., 256–11th St., Milwaukee, Wis.

DOYLE, William J. (*M* 1920), Des. Engr., Williamson Heater Co., 4558 Marburg Ave., Oakley, Cincinnati, and (for mail), 3766 Hyde Park Ave., Cincinnati, O.

DRESEN, W. D. (*A* 1929; *J* 1926), Asst. Engr. (for mail), Thermal Units Co., 39th and Loomis Sts., and 340 N. Pine Ave., Chicago, Ill.

DRIGGS, Leland L. (*M* 1918), Htg. Engr., United Engineers & Constructors, 112 N. Broad St., Philadelphia, Pa., and (for mail), 208 E. Clinton Ave., Oaklyn, N. J.

DRINKER, Philip* (*M* 1922), Asst. Prof. of Ventilation and Illumination (for mail), Harvard School of Public Health, 55 Van Dyke St., Boston, and 11 Lowell Rd., Brookline, Mass.

DRISCOLL, William H. (*M* 1904), (*Presidential Member*), (Pres., 1926; 1st Vice-Pres., 1925; 2nd Vice-Pres., 1924; Treas., 1923; Council 1918-1927), 23 Boyd Ave., Jersey City, N. J.

DRUCE, John James (*M* 1922), Vice-Pres., McKelvey & Birch, Ltd., 69 Brock St., and (for mail), 96 Queens Crescent, Kingston, Ont., Can.

DUBÉ, Wilbrod (*M* 1925), Raoul Chenevert, Archt., Sun Trust Bldg., 132 St. Pierre, and (for mail), 316 Laurier Ave., Quebec, Can.

DUBRY, Ernest E. (*M* 1924), Asst. Supt., Central Htg. (for mail), The Detroit Edison Co., 2000 Second Ave., and 9116 Dexter Blvd., Detroit, Mich.

DUDFIELD, Alvin (*M* 1920), Gen. Mgr., Dudfield Mfg. Co., 116 W. Kansas St., Liberty, Mo.

DUDLEY, William Lyle (*M* 1922), Vice-Pres. and Chief Engr. (for mail), Western Blower Co., 1800 Ninth Ave. S., and 334 McGilvra Blvd., Seattle, Wash.

DUEMLER, Franklin C. (*J* 1926), Sales Engr., Pacific Steel Boiler Corp., S. E. Cor. 22nd St. and Sedgley Ave., Philadelphia, and (for mail), 1032 E. Rittenhouse St., Germantown, Philadelphia, Pa.

DUFF, Kennedy (*M* 1915), Johnson Service Co., 28 East 29th St., New York, N. Y.

DUFFIELD, Thomas Jefferson* (*A* 1927), 400 West 119th St., New York, N. Y.

DUGAN, Thomas M. (*M* 1920), Engr., National Tube Co., Fourth Ave. and Locust St., and (for mail), 1308 Freemont St., McKeesport, Pa.

DUNCAN, George W., Jr. (*M* 1923), Consulting Engr. (for mail), Dean & Dean, Archts., California State Life Bldg., and The Hermitage Club, 2115 G St., Sacramento, Calif.

DUNHAM, C. A.* (*M* 1911), Pres. (for mail), C. A. Dunham Co., Dunham Bldg., 450 E. Ohio St., Chicago, and Glencoe, Ill.

DUNLAP, Ralph L. (*M* 1917), J. H. Kitchen & Co., 1012 Pioneer Trust Bldg., 1016 Baltimore Ave., Kansas City, Mo.

DURAND, William L. (*M* 1921), Clark McMullen & Riley, 101 Park Ave., New York, N. Y.

DUSSOSSOIT, Edmond A. (*M* 1920), Treas. (for mail), Lynch & Woodward, Inc., 320 Dover St., Boston, and 16 Hancock Ave., Newton Centre, Mass.

DWYER, Thomas F. (*M* 1923), Board of Education, Concord St. and Flatbush Ave., Brooklyn, N. Y.

DYER, Orville K. (*M* 1919), Mgr., Blower Dept. (for mail), Buffalo Forge Co., 490 Broadway, and 11 Russell Ave., Buffalo, N. Y.

◆

EADIE, John G. (*M* 1906), Eadie, Freund & Campbell, 110 West 40th St., New York, N. Y.

EAGAN, Walter H. (*M* 1926), Walter H. Eagan & Co., 1612 Vine St., Philadelphia, Pa.

EAGAR, R. Frank (*M* 1922), 138 Lower Water St., Halifax, N. S.

EAKINS, Walter (*M* 1928), L. J. Sommer & Son., Inc., 2436 Brown St., Philadelphia, Pa.

EARLY, George D. (*A* 1927), Business Repr. (for mail), Steamfitters Union, Labor Temple, and 3404 E. Marion St., Seattle, Wash.

EASTERBROOKS, Clifton C. (*M* 1922), Sales Engr. (for mail), Koithan & Pryor, 39 Cortlandt St., and 2735 Sedgwick Ave., New York, N. Y.

EASTWOOD, E. O. (*M* 1921), Prof. of Mech. Engrg. (for mail), University of Washington, and 4702–12th Ave. N. E., Seattle, Wash.

EASTWOOD, Harry F. (*M* 1925), Vice-Pres. and Chief Engr. (for mail), Combustion Specialties Corp., 101-109 East 144th St., New York, and 157 Frankel Blvd., Merrick, L. I., N. Y.

EATON, Byron K. (*M* 1920; *A* 1919), 500 Sunset Ave., La Grange, Ill.

EATON, Phillips (*M* 1927), 40 Caldwell St., Woodfords, Maine.

EATON, Roy (*A* 1925), Salesman, Pierce, Butler & Pierce, 340 C St., Boston, and (for mail), 546 Broad St., E. Weymouth, Mass.

EBERLE, Carl Frederick (*A* 1929; *J* 1926), 121 N. Main St., Zelienople, Pa.

EBERT, William A. (*M* 1920), Engr. and Estimator (for mail), A. H. Shafer, P. O. Box 1280, and 1004 Drexel Ave., San Antonio, Tex.

EBIN, Louis* (*M* 1924), Htg. and Vtg. Engr., Phillips, Getschow Co., 421 N. State St., Chicago, Ill.

ECKARDT, Charles A. T. (*A* 1924), 456 Irvington Rd., Drexel Park, Pa.

ECKART, Claude H. (*M* 1915), Secy-Treas. (for mail), Eckart Bros., Inc., 419 Eighth Ave. N., and 9675–48th St. S. W., Seattle, Wash.

ECKLES, Robert Arthur (*M* 1926), L. S. & T. Bldg., New Castle, Pa.

EDDY, William Horace (*A* 1927), 802 E. Fifth St., Superior, Wis.

EDGAR, Andrew C. (*Charter Member*). (Council, 1920), Director, Certified Htg. Association, Inc., 1202 Locust St., Philadelphia, Pa.

EDWARDS, Daniel F. (*M* 1920), 2340-42 Pine St., St. Louis, Mo.

EDWARDS, Paul A. (*M* 1919), The G. F. Higgins Co., 606 Wabash Bldg., Pittsburgh, Pa.

EDWARDS, Ralph H. (*A* 1928), Sink & Edwards, 621 E. Ohio St., Indianapolis, Ind.

EELLS, Henry B. (*M* 1926), 1049 East 27th St., Brooklyn, N. Y.

EGGLESTON, Lewis W. (*M* 1921), American Radiator Co., 5961 Lincoln Ave., Detroit, Mich.

EHRENZELLER, Adolphe (*M* 1924), Walker & Pratt Mfg. Co., 31 Union St., Boston, Mass.

EHRLICH, M. William* (*M* 1916), Mgr., The Trane Co., 15 Park Row, New York, N. Y., and (for mail), 56 Ridge Rd., Lyndhurst, N. J.

EICHBERG, W. Roy (*M* 1929), Pres. (for mail), Carolina Sheet Metal Works, 3009 Chestnut St., Philadelphia, and 828 Turner Ave., Drexel Hill, Pa.

EICHER, Dr. Hubert C. (*M* 1922), 103 South St., Harrisburg, Pa.

EICHLER, Alvin (*M* 1919), Eichler Htg. Co., 2010 Railway Exchange Bldg., St. Louis, Mo.

EISERT, Herman* (*M* 1920), 4007 Bateman Ave., Baltimore, Md.

ELLIOT, Edwin (*M* 1929), (for mail), Edwin Elliot & Co., 560 North 16th St., Philadelphia, and 403 W. Price St., Germantown, Philadelphia, Pa.

ELLIS, Ernest E. (*M* 1922), F. A. Ellis & Sons, 840 Center St., Winnetka, Ill.

ELLIS, F. R. (*M* 1913), Sales Engr., Buerkel & Co., Inc., 18-24 Union Park St., Boston, and (for mail), 131 Beacon St., Hyde Park, Mass.

ELLIS, Harry W. (*M* 1923; *A* 1909), Johnson Service Co., 149 Michigan St., Milwaukee, Wis.

ELLIS, Wilbur H. (*A* 1927; *J* 1926), Htg. and Vtg. Estimator, J. L. Murphy, Inc., 340 East 44th St., and (for mail), 29 Maple St., Irvington, N. Y.

ELLISON, J. Huyler (*M* 1919), 41 Wallace St., Freeport, N. Y.

ELY, F. Ernest (*A* 1925), Taylor Instrument Co., 31 Union Sq., New York, N. Y.

EMERSON, Ralph R. (*M* 1922), Hoffman Specialty Co., 25 West 45th St., New York, N. Y.

EMERY, William D. (*M* 1923), Pres. (for mail), Blest & Emery Co., Inc., 784 Coney Island Ave., and 496 Argyle Rd., Brooklyn, N. Y.

EMMETT, Luther D. (*M* 1919), Buffalo Forge Co., 562 W. Washington Blvd., Chicago, Ill.

EMSWILER, John E.* (*M* 1917), Prof. of Mech. Engrg. (for mail), University of Michigan, 231 W. Engineering Bldg., and 1303 Granger Ave., Ann Arbor, Mich.

ENGLE, Alfred (*A* 1923), Asst. Sales Mgr. (for mail), Jenkins Bros., 80 White St., New York, and 445 Gramatan Ave., Mt. Vernon, N. Y.

ENGLISH, Alpheus T. (*A* 1926), Dist. Mgr., The Columbus Htg. & Vtg. Co., 638 Wabash Bldg., Pittsburgh, Pa.

ENSIGN, Ralph M. (*M* 1917), Pres., The Ensign Engrg. Co., 35 E. Wacker Dr., and (for mail), 411 Fullerton Pkwy., Chicago, Ill.

ERICKSON, Harry A. (*M* 1917), Engr. and Estimator (for mail), Bureau of Quantity Surveys, Inc., 314 Keyser Bldg., and 3716 Nortonia Rd., Baltimore, Md.

ERICKSON, Martin E. (*A* 1926), 587–66th Ave., West Allis, Wis.

ERON, Lewis J. (*M* 1925), Engr. (for mail), Eron Plbg. & Htg. Co., 195 Second St. N., and 931 Gardner St., Wisconsin Rapids, Wis.

ERTMAN, Bernard Rust (*M* 1920), 309 N. Main St., Herkimer, N. Y.

EVANS, C. A. (*M* 1919), 218 Lexington Ave., Buffalo, N. Y.

EVANS, Edwin C. (*M* 1919), Dist. Repr., Reed Air Filter Co., 985 Union Trust Bldg., and (for mail), 2953 Zephyr Ave., Corliss Sta., Pittsburgh, Pa.

EVANS, Howard (*M* 1926), Mgr. (for mail), Howard Evans Engrg. Specialties, 406 Hernando Bldg., and R. F. D. 7, Lexington, Ky.

EVANS, John (*M* 1919), 30 Water St., Galt, Ont., Can.

EVANS, William A. (*M* 1918), 24 Woodland Rd., Maplewood, N. J.

EVELETH, Charles F. (*M* 1911), Engr. (for mail), C. W. Colby & Co., 2341 Carnegie Ave., and 2030 East 115th St., Cleveland, O.

EVLETH, Everett B. (*A* 1927), Br. Mgr. (for mail), Minneapolis-Honeywell Regulator Co., 2831 Olive St., and 1258 Moorland Dr., St. Louis, Mo.

EWING, Dell R. (*A* 1928), Ruud Mfg. Co., 875 Main St., Buffalo, N. Y.

F

FABER, Guy Stanley (*M* 1926), J. P. Marsh & Co., 2073 Southport Ave., Chicago, Ill.

FALVEY, John D. (*M* 1922), Hester-Bradley Co., 4200 Forest Park Blvd., St. Louis, Mo.

FANSLER, P. E. (*A* 1927), Editor (for mail), Oil Heat, 167 Madison Ave., New York, N. Y., and 94 Hobson St., Stamford, Conn.

FARLEY, John W. (*A* 1921), Mgr., Farley Sleeve & Hanger Co., 3748 East 71st St., Cleveland, O.

FARNHAM, Roswell (*M* 1920), (Council, 1927-1929), Dist. Mgr., Engrg. Sales (for mail), Buffalo Forge Co., P. O. Box 985, and 5 Clarendon Pl., Buffalo, N. Y.

FARRAR, Cecil W. (*M* 1920; *A* 1918), Pres. (for mail), Excelso Products Corp., 65 Clyde Ave., and 29 Oakland Pl., Buffalo, N. Y.

FAULKNER, Dwight H. (*M* 1926), Engr., The H. B. Smith Co., 10 East 41st St., New York, and (for mail), 46 Parsons Dr., Hempstead, N. Y.

FAY, Francis C. (*M* 1925), Raisler Htg. Co., 129-31 Amsterdam Ave., New York, N. Y.

FEBREY, Ernest J. (*M* 1903), Senior Member (for mail), E. J. Febrey & Co., 616 New York Ave. N. W., Washington, and 3770 McKinley St., Chevy Chase, D. C.

FEELY, Frank J. (*A* 1929), 2274 Calvert, Detroit, Mich.

FEEHAN, John B. (*M* 1923), Pres. and Treas. (for mail), John B. Feehan, Inc., 471 Union St., Lynn, and 82 Sargent St., Winthrop, Mass.

FEHLIG, John B. (*M* 1918), Pres. (for mail), Excelsior Htg. Supply Co., 528-30 Delaware St., and 2927 Brooklyn Ave., Kansas City, Mo.

FELDMAN, A. M.* (*M* 1903), Consulting Engr. (for mail), 145 West 45th St., and 124 West 93rd St., New York, N. Y.

FELS, Arthur B. (*M* 1919), The Fels Co., 60 Union St., Portland, Me.

FELTWELL, R. H. (*M* 1905), Dist. Mgr., D. & T. Mfg. Co., St. Louis, Mo., and (for mail), 1040 S. Frazier Ter., Philadelphia, Pa.

FENNER, Everett M. (*A* 1928), Engr. and Mgr., F. J. Rooney Co., Commercial Trust Bldg., New Britain, Conn.

FENNER, N. Paul (*A* 1928; *J* 1927), (for mail), Hoffman Specialty Co., Waterbury, Conn., and Watertown, Conn.

FENSTERMAKER, S. E. (*M* 1909), Pres. (for mail), S. E. Fenstermaker & Co., Architect and Builders Bldg., Pennsylvania and Vermont Sts., and 3102 Washington Blvd., Indianapolis, Ind.

FERGUSON, R. R. (*J* 1925), Mgr. (for mail), American Blower Corp., 1221 Boatmen's Bk. Bldg., and 609 Hamilton Ave., St. Louis, Mo.

FEST, Leon T. (*M* 1919), Mgr. Phila. Br., Pierce, Butler & Pierce Mfg. Corp., 31st & Oxford Sts., and (for mail), 6646 North 18th St., Philadelphia, Pa.

FESTORAZZI, A. O. (*J* 1925), C. P. Lichty Engrg. Co., Inc., 507 North 22nd St., Birmingham, Ala.

FIEDLER, Harry W. (*M* 1923), 49 Palmer Ave., Scarsdale, N. Y.

FIELDING, Howard H. (*M* 1904), (Council, 1917-1919), Htg. & Vtg. Engr. (for mail), 1226 California St., and 607East 10th Ave., Apt. 2, Denver, Colo.

FIFE, George Donald (*A* 1929), Estimating Dept., Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, N. J., and (for mail), 102 East 22nd St., New York, N. Y.

FILSON, Foster E. (*M* 1924), (for mail), 107 Cherry St., Harrisburg, and 19 N. Second St., Wormleysburg, Pa.

FINAN, Edward J. (*A* 1926), Engr., Board of Education, Chicago, and (for mail), 7149 Euclid Ave., Chicago, Ill.

FINAN, James J. (*M* 1923), Supervising Engr., City of Chicago, Board of Education, 650 S. Clark St., and (for mail), 7149 Euclid Ave., Chicago, Ill.

FIRSCHING, Frank J. (*M* 1921), Warren Webster & Co., 1005 Empire Bldg., Pittsburgh, Pa.

FISHER, Edwin L. (*A* 1928), 3224 N. Third St., Harrisburg, Pa.

FITCH, Walter S. (*M* 1926), Dennison Mfg. Co., 300 Howard St., Framingham, Mass.

FITZ, Jean Chandler (*M* 1925), 4213 Darien St., Philadelphia, Pa.

FIX, Frederick W., Jr. (*A* 1927), Treas. (for mail), Kellogg-Mackay Co., 1351 West 37th Pl., Chicago, and 535 Hinman Ave., Evanston, Ill.

FLEISHER, Walter L. (*M* 1914), Air Conditioning Engr. (for mail), Room 2330, 11 West 42nd St., New York, and New City, Rockland County, N. Y.

FLEMING, James P. (*M* 1923), Board of Education, 1410 N. Rockwell St., Chicago, Ill.

FLEMING, Thomas C. (*M* 1919), Asst. Mgr., Crane Co., 1301 Locust St., and (for mail), 5239 North 15th St., Philadelphia, Pa.

FLEMINGS, John A. (*M* 1929), Mgr., N. E. Br. (for mail), Spencer Heater Co., 216 Tremont St., Boston, and 21 S. Main St., Sharon, Mass.

FLEMMING, Walter L. (*A* 1929; *J* 1928), W. F. Hirschman Co., 525 Sixth Ave., New York, N. Y.

FLETT, Henry R. (*M* 1915), (for mail), 1088 King St. W., Toronto 2, and 170 Indian Rd., Toronto 3, Ont., Can.

FLINK, Carl H. (*M* 1923), Asst. Director Gas Utilization Dept. (for mail), American Radiator Co., 40 West 40th St., New York, and 324 First Ave., N. Pelham, N. Y.

FLINT, Coll T. (*M* 1919), Sales Mgr. (for mail), The H. B. Smith Co., 640 Main St., Cambridge, and 56 Brantwood Rd., Arlington, Mass.

FOLEY, William J. (*A* 1923), Pres. and Mgr. (for mail), Wm. J. Foley Co., 230–15th St., and 360 Colorado Blvd., Denver, Colo.

FOLLEY, E. B. (*M* 1928), Gaylord & Eitapence Co., 179 Washington St., Binghamton, N. Y.

FORFAR, Donald M. (*M* 1917), Mech. Engr. (for mail), Grinnell Co., 240 Seventh Ave. S., and 4817 Emerson Ave. S., Minneapolis, Minn.

FORGEE, Frederick A. (*M* 1911), Box 433, Ridgewood, N. J.

FORSBERG, William (*M* 1919), Hopson & Chapin Mfg. Co., 231 State St., New London, Conn.

FORTUNE, J. Robert (*M* 1929), Mgr., Htg. Div., The Wickes Boiler Co., Saginaw, Mich., and (for mail), 201 E. Kirby St., Detroit, Mich.

FOSTER, Charles (*M* 1923), Consulting Engr. (for mail), 512 Sellwood Bldg., and 2831 E. First St., Duluth, Minn.

FOSTER, James M. (*A* 1920), Dist. Mgr. (for mail), Ilg Elec. Vtg. Co., 915 Olive St., and 7021 Lindell Blvd., St. Louis, Mo.

FOSTER, William M. (*A* 1914), 16508 Woodward Ave., Highland Park, Mich.

FOUILHOUX, J. Andre (*M* 1915), West Rd., Short Hills, N. J.

FOULDS, P. A. L. (*M* 1916), Mech. Engr. (for mail), Hollis French & Allen Hubbard, Consulting Engrs., 210 South St., Boston, and 72 Whitin Ave., Point of Pines, Revere, Mass.

FRANK, John M. (*M* 1918; *A* 1912), Pres. (for mail), Ilg Elec. Vtg. Co., 2850 N. Crawford Ave., Chicago, and 1152 Chatfield Rd., Hubbard Woods, Ill.

FRANK, Mrs. Olive E.* (*M* 1919), Pres. (for mail), O. E. Frank Heater & Engrg. Co., 20 Milburn St., and 296 Norwalk Ave., Buffalo, N. Y.

FRANKEL, Gilbert (*M* 1926), Buffalo Forge Co., 490 Broadway, Buffalo, N. Y.

FRANKLIN, Ralph S. (*M* 1919), Pres. and Treas. (for mail), Albert B. Franklin, Inc., 25 Haverhill St., Boston, and 320 Grove St., Melrose, Mass.

FRANZHEIM, George W. (*M* 1924), Universal Smokeless Boiler Co., Ravenna, O.

FRASER, William G. (*M* 1916), Power Efficiency Corp., 137 Arthur St., Buffalo, N. Y.

FREAS, Royal Bruce (*M* 1928). Thermo Elec. Instrument Co., 1206 S. Grove St., Irvington, N. J.

FRENCH, Donald E. (*M* 1926), Vice-Pres. (for mail), York Htg. & Vtg. Corp., 1541 Sansom St., Philadelphia, and Rockland Rd., Merion, Pa.

FREYN, Harry L. (*A* 1928), 1028 N. Illi St., Indianapolis, Ind.

FRIEDMAN, Abraham (*M* 1922), Friedman & Kiss, Inc., 207 East 43rd St., New York, N. Y.

FRIEDMAN, Ferdinand J. (*M* 1921), Mech. Engr., McDougall & Friedman, 31 Union Sq., New York, N. Y.

FROST, Robinson V.* (*M* 1921), Pres., Frost Research Lab., Inc., 1326 Markley St., Norristown, Pa.

FRUTCHEY, Marcus Peter, Jr. (*J* 1927), 59 Grove Ave., Verona, N. J.

FRUTCHY, Asel E. (*M* 1924; *J* 1920), Vice-Pres. (for mail), Frutchy-Barnes Co., Inc., 104 W. Second St., and 864 Euclid Ave., Elmira, N. Y.

FRYER, Frederick G. (*M* 1918), Director (for mail), Rowntree & Co., Ltd., and Beech House, York, England.

FUKUI, Kunitaro (*M* 1927), Fukui & Co., Tokyo Kaiji Bldg., Marunouchi, Tokyo, Japan.

FULLER, John L. (*A* 1916), Mgr. (for mail), John L. Fuller Co., 459 York St., and 1745 Chicago Blvd., Detroit, Mich.

FUNCK, Elmer H. (*A* 1928; *J* 1926), Johnson Fan & Blower Co., 1319 W. Lake St., Chicago, Ill.

G

GABELMANN, P. Edward (*J* 1929), Engr., Pacific Engrg. Equipment Corp., 972 Broad St., and (for mail), 62 Dayton St., Newark, N. J.

GABY, F. A. (*M* 1926), Chief Engr. (for mail), Hydro Elec. Power Commission, 190 University Ave., and 480 Spading Rd., Toronto, Ont., Can.

GALE, Thomas J. G. (*M* 1921; *A* 1920), 2705 S. Kingshighway, St. Louis, Mo.

GALLAHER, A. J. (*M* 1926), Gallaher Boiler Co., 508 Star Bldg., St. Louis, Mo.

GALLAHER, James E. (*M* 1927; *A* 1923; *J* 1923), B. F. Reynolds Co., 487 W. Alexandrine Ave., Detroit, Mich.

GALLIGAN, Andrew B. (*M* 1921), 716 South 51st St., Philadelphia, Pa.

GALLIGAN, John H. (*M* 1923), Treas. (for mail), Marine Galligan Co., 14 South 20th St., and 1930 South 56th St., Philadelphia, Pa.

GANT, H. P.* (*M* 1915), (*Presidential Member*), (Pres., 1923; 1st Vice-Pres., 1922; 2nd Vice-Pres., 1921; Council, 1918-1924), York Htg. & Vtg. Corp., York Bldg., 16th and Sansom St., Philadelphia, Pa.

GARDNER, Benjamin F. (*M* 1924), Htg. Contractor, 322 Myrtle Ave., and (for mail), 277 Carlton Ave., Brooklyn, N. Y.

GARDNER, S. Franklin (*M* 1911). Member of Firm (for mail), Standard Engrg. Co., 2129 Eye St. N. W., and 3805 Kanawha St., Washington, D. C.

GARDNER, W., Jr. (*A* 1921), Sales Mgr. (for mail), Garden City Fan Co., McCormick Bldg., and 7836 Loomis Blvd., Chicago, Ill.

GASSLER, John H. (*J* 1927), Htg. Engr., Crane Co., 738 West Bay St., and (for mail), P. O. Box 4242, Jacksonville, Fla.

GAST, Charles (*M* 1928), 2 Rutland Ave., Rockville Center, N. Y.

GAULIN, Richard P. (*J* 1925), Sales Engr. (for mail), Hoffman Specialty Co., 1346 Broadway, and Webster Hall, Detroit, Mich.

GAUSMAN, Carl E. (*M* 1923), 2360 Chilcombe, St. Paul, Minn.

GAUVIN, Leon Gough (*M* 1926), 45 E. Delavan Ave., Buffalo, N. Y.

GAWTHROP, Fred H. (*M* 1919), 2211 Shallcross Ave., Wilmington, Del.

GAYLOR, William S. (*M* 1919), Htg. and Vtg. Engr., Starrett & Van Vleck, Architects., 393 Seventh Ave., New York, and (for mail), 42 Mayhew Ave., Larchmont, N. Y.

GAYLORD, F. H. (*M* 1921), Asst. Sales Mgr. (for mail), Hoffman Specialty Co., 130 N. Wells St., Chicago, and 362 N. York St., Elmhurst, Ill.

GEIGER, Irvin H. (*M* 1923), 600 Second St., Room 803, Harrisburg, Pa.

GEMENY, William J. (*M* 1919), W. J. Gemeny Co., 2528 W. Madison St., Chicago, Ill.

GERRISH, Harry E. (*M* 1910), (Council, 1919), Partner (for mail), Morgan-Gerrish Co., 800 La Salle Ave., and 4534 S. Freemont Ave., Minneapolis, Minn.

GETSCHOW, George M. (*M* 1906), Pres. and Treas. (for mail), Phillips-Getschow Co., 421 N. State St., and 4542 Beacon St., Chicago, Ill.

GETSCHOW, Roy M. (*M* 1919), Secy. (for mail), Phillips-Getschow Co., 421 N. State St., and 4542 Beacon St., Chicago, Ill.

GIANNINI, Aldo C. (*J* 1929), Estimator, Wolff & Munier, Inc., 222 East 41st St., and (for mail), 64 West 176th St., New York, N. Y.

GIBBONS, M. J., Jr. (*M* 1914), Owner, M. J. Gibbons Supply Co., 601-631 E. Monument Ave., and (for mail), 22 Oxford Ave., Dayton, O.

GIBBS, Edward W. (*M* 1919), (for mail), The Smith-Gibbs Co., 201 S. Main St., and 61 President Ave., Providence, R. I.

GIBBS, Frank C. (*M* 1921), Gen. Supt. (for mail), National Regulator Co., 2301 Knox Ave., Chicago, and 430 S. Oak Park Ave., Oak Park, Ill.

GIESECKE, Frederick E.* (*M* 1913), Director Engrg. Experimental Sta., Agricultural and Mechanical College of Texas, College Sta., Tex.

GIFFORD, Edmund W. (*J* 1929), Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, N. J.

GIFFORD, Robert Fulton (*M* 1927), Mgr., Robert F. Gifford Co., 89 Broad St., Boston, Mass.

GIFFORD, Robert L. (*M* 1908), 1231 S. El Molino Ave., Pasadena, Calif.

GIGUERE, George H. (*M* 1920), 800 Marquette Bldg., Detroit, Mich.

GILBOY, John P. (*M* 1924), Owner (for mail), John P. Gilboy Co., 810 Scranton Elec. Bldg., and 1725 Olive St., Scranton, Pa.

GILLETT, M. C. (*M* 1916), Asst. Sales Mgr., Hoffman Specialty Co., Waterbury, Conn., and (for mail), 6600 Rising Sun Ave., Philadelphia, Pa.

GILLHAM, Walter E. (*M* 1917), (Treas., 1926-1929; Council, 1926-1929), 409 Interstate Bldg., Kansas City, Mo.

GILLING, William F. (*A* 1919), Asst. Mgr., American Radiator Co., 129 Federal St., Boston, and (for mail), 29 Abbott Rd., Wellesley Hills, Mass.

GILMORE, Frank P. (*M* 1923), Sales Engr., Peerless Unit Ventilation Co., 80 Boylston St., Boston, Mass.

GILMORE, R. E. (*M* 1923), 4243 Sheridan Rd., Chicago, Ill.

GIVIN, Albert W. (*A* 1925), Mgr. (for mail), Taylor-Forbes Co., Ltd., 1070 Homer St., and 1075 Gilford St., Vancouver, B. C.

GLASSEY, J. Wilbur (*M* 1922), Vapor Engrg. Co., 10 South 18th St., Philadelphia, Pa.

GLEASON, Gilbert H. (*M* 1923), 25 Huntington Ave., Boston, Mass.

GLORE, Evins Foree (*A* 1916), 639 West End Ave., New York, N. Y.

GOERG, Bernhard (*M* 1928), American Radiator Co., 675 Bronx River Rd., Yonkers, N. Y.

GOETHEL, Alfred C. (*A* 1926), 829–31st St., Milwaukee, Wis.

GOLDBERG, Harry M. (*A* 1927; *J* 1923), 41 Fifth Ave., New York, N. Y.

GOLDSCHMIDT, Otto E. (*M* 1915), Consulting Engr. (for mail), 116 West 39th St., and 215 West 92nd St., New York, N. Y.

GOLDSTEIN, A. M. (*M* 1923), Federal Htg. Co., 1501 Varnum St., Washington, D. C.

GOMBERS, Henry B. (*A* 1901), Secy. (for mail), Heating and Piping Contractors National Assn., 50 Union Sq., New York, N. Y., and 160 Halsted St., E. Orange, N. J.

GOMERSALL, William H. (*A* 1921), 7428 Fayette St., Germantown, Philadelphia, Pa.

GOOD, Macy S. (*M* 1921), Mgr. (for mail), C. A. Dunham Co., 450 E. Ohio St., and 7350 Phillips Ave., Chicago, Ill.

GOODHUE, Albion Paris (*M* 1928), Herman Nelson Corp., 43 Court St., Belfast, Maine.

GOODNOW, Wallace F. (*M* 1912), Pierce, Butler & Pierce, 41 East 42nd St., New York, N. Y.

GOODRICH, Charles F. (*M* 1919), Andrews & Goodrich, Inc., 98 Friend St., Boston, Mass.

GOODWIN, Samuel L. (*M* 1924), Consulting Engr., Thomas W. Lamb, Architect, 644 Eighth Ave., New York, N. Y., and (for mail), 247 Madison Ave., Hasbrouck Heights, N. J.

GORDON, Edward B., Jr. (*M* 1908), 3025 S. Emerson, Minneapolis, Minn.

GORDON, Edward G. (*M* 1923), 6655 Ogallah Ave., Chicago, Ill.

GORMLY, Patrick (*Life Member; M* 1898), R. D. 5, Norristown, Pa.

GORNSTON, Michael H. (*A* 1923), 251 Crescent St., Brooklyn, N. Y.

GORTNER, John W. (*M* 1919), 318 Sunbury St., Shamokin, Pa.

GOSSETT, Earl J. (*M* 1923), Pres. (for mail), Bell & Gossett Co., 3000 Wallace St., Chicago, and 314 Woodland Ave., Winnetka, Ill.

GOTTWALD, C. (*A* 1916), Pres. (for mail), The Ric-wiL Co., 1562 Union Trust Bldg., Cleveland, and 2225 Stillman Rd., Cleveland Heights, O.

GRAHAM, Charles D. (*M* 1929; *J* 1927), Mgr., Engrg. Dept. (for mail), York Htg. & Vtg. Corp., 1541 Sansom St., Philadelphia, and 39 W. Athens Ave., Ardmore, Pa.

GRAHAM, William D. (*M* 1929; *A* 1925; *J* 1923), Dist. Mgr. (for mail), York Htg. & Vtg. Corp., 205 W. Wacker Dr., and 1100 Mohawk Rd., Wilmette, Ill.

GRAHN, Victor F. (*M* 1927), Htg. and Vtg. Engr., Tenney & Ohmes, Inc., 101 Park Ave., New York, N. Y., and (for mail), 120 Greenwood Ave., E. Orange, N. J.

GRANT, Albert E. (*M* 1928), 3305 Broadway, New York, N. Y.

GRANT, Walter A. (*J* 1929), Jr. Engr., Carrier Engrg. Corp., Newark, N. J., and (for mail), 419 West 121st St., New York, N. Y.

GRAU, Earl R. (*J* 1929), Sales Engr., Samuel Sloan & Co., 67 Exchange St., and (for mail), 380 Ridgeway Ave., Rochester, N. Y.

GRAVES, Clarence C. (*A* 1925), Secy-Treas. (for mail), Graves & Graves, Inc., 3047 Sheffield Ave., Lake View Sta., and 4110 N. Kilbourn Ave., Irving Park Sta., Chicago, Ill.

GRAVES, Ralph E. (*A* 1923), R. R. 13, Osage Hills, Kirkwood, Mo.

GRAVES, Willard B. (*M* 1906), 162 N. Desplaines St., Chicago, Ill.

GRAY, George A. (*M* 1924), C. A. Dunham Co., Ltd., 404 Plaza Bldg., Ottawa, Ont., Can.

GRAY, W. E. (*M* 1922), Sales Engr., Powers Regulator Co., Chicago, Ill., and (for mail), 707 E. Lexington Ave., High Point, N. C.

GREBE, Henry W. (*M* 1919), Central Asbestos & Magnesia Co., 214 W. Grand Ave., Chicago, Ill.

GREEN, John E. (*A* 1926), Owner (for mail), John E. Green, 11820 Brush St., Highland Park, and 2411 Glynn Court, Detroit, Mich.

GREEN, William C. (*M* 1906), Warren Webster & Co., 919 Provident Bank Bldg., Cincinnati, O.

GREENE, Walter C. (*M* 1921), Mgr. (for mail), Walter C. Greene Co., 1600 Union Trust Bldg., and 2605 Guilford Rd., Cleveland, O.

GRIER, William (*M* 1908), P. O. Box 75, Cincinnati, O.

GRIFFIN, Byron Henry (*M* 1928), 2150 Bedford Ave., Brooklyn, N. Y.

GRIFFIN, John J. (*M* 1928), Sales Repr. (for mail), Hoffman Specialty Co., Waterbury, Conn., and 3718 Hillsdale Rd., Baltimore, Md.

GRIFFIN, Porter C. (*M* 1923), Supt., The Hutton Bros. Co., 9 Union St., and (for mail), 151 Oak St., Winsted, Conn.

GRIFFITHS, Morgan R. (*A* 1922), Mgr. (for mail), Canadian Blower & Forge Co., Ltd., 146 King St. W., and 55 Constance St., Toronto, Ont., Can.

GRILL, Guido E. (*A* 1928; *J* 1922), Clark, McMullen & Riley, 101 Park Ave., New York, N. Y.

GRONBERG, C. E. (*A* 1928), 1617 Cleburne Ave., Birmingham, Ala.

GROOM, Stanley L. (*M* 1920), Homestead Thrale Rd., Streatham, London, England.

GROSS, Raymond A. (*M* 1923), 527 N. Washington St., Park Ridge, Ill.

GROSS, Samuel (*M* 1929), Treas. (for mail), Sheffler-Gross Co., Inc., 203-11 Drexel Bldg., Philadelphia, and 537 E. Church Rd., Elkins Park, Pa.

GROSSMAN, Harry E. (*J* 1927), Hoffman Specialty Co., Inc., Waterbury, Conn., and (for mail), 1122 Wyoming Ave., Forty Fort, Pa.

GROSSMAN, Howard M. (*M* 1922), Dist. Sales Mgr., Burnham Boiler Corp., 701 Griest Bldg., and (for mail), 634 Race Ave., Lancaster, Pa.

GROSVOLD, Fred E. (*M* 1917), 411 Grand Ave., E., Eau Claire, Wis.

GROTZ, Arthur B. (*M* 1921), 59 Old Orchard Lane, Scarsdale, N. Y.

GUNTHER, Felix A. (*M* 1925), Sales Engr. (for mail), Direct Control Valve Co., 1007 Diamond Bk. Bldg., and P. O. Box 137, R. F. D. No. 9, South Hills Br., Pittsburgh, Pa.

GURNEY, Edward Holt (*M* 1929), Pres. (for mail), The Gurney Foundry Co., Ltd., 500 W. King St., and 347 Walmer Rd., Toronto, Ont., Can.

H

HAAS, Samuel L. (*M* 1923), Pres. and Treas. (for mail), Advance Htg. Co., 117 N. Desplaines St., and 1513 Fargo Ave., Chicago, Ill.

HAAS, William (*M* 1915), 429 E. Third St., Dayton, O.

HACKETT, Charles P. (*A* 1921), Htg. Dept., Hajoca Corp., 120 South 30th St., Philadelphia, and (for mail), 56 W. Eagle Rd., Upper Darby, Pa.

HACKETT, H. Berkeley (*M* 1921), Public Ledger Bldg., Philadelphia, Pa.

HADDOCK, Isaac T. (*A* 1926), Cambridge Gas Light Co., 719 Massachusetts Ave., Cambridge, Mass.

HADEN, George N. (*A* 1928; *J* 1922), G. N. Haden & Sons, Ltd., 60 Kingsway, W. C. 2, London, England.

HADEN, William Nelson (*Life Member; M* 1902), Chairman, G. N. Haden & Sons, Ltd., St. Georges Works, and (for mail), Trowbridge, England.

HADESTY, Alfred L., Jr. (*M* 1921), Owner, Alfred L. Hadesty, Jr., 130 E. Broad St., Tamaqua, Pa.

HAGAN, William V. (*J* 1926), Secy., V. J. Hagan Co., 506 Pearl St., and (for mail), 301 Metz Apts., Sioux City, Iowa.

HAGEDON, Charles H. (*M* 1919), Secy-Treas. (for mail), S. E. Fenstermaker & Co., 939 Architects & Builders Bldg., and 4156 Broadway, Indianapolis, Ind.

HAILEY, Syd Houston (*M* 1925), Asst. Engr., N. C. and St. Louis Railway, 924 Broadway, and (for mail), 3737 Harding Rd., Nashville, Tenn.

HAINES, John J. (*M* 1919), Pres. (for mail), The Haines Co., 1931 W. Lake St., Chicago, and 623 17th Ave., Maywood, Ill.

HAKES, Leon Marc (*J* 1929), Sales Engr. (for mail), The R. T. Coe Cos., 907 Gas & Elec. Bldg., and 345 Lake Ave., Apt. 5, Rochester, N. Y.

HALE, John F. (*M* 1902), (*Presidential Member*), (Pres., 1913; 1st Vice-Pres., 1912; Board of Governors, 1908, 1910, 1912, 1913), Dist. Mgr. (for mail), Aerofin Corp., 1531-160 N. La Salle St., Chicago, and 408 S. Brainard Ave., La Grange, Ill.

HALEY, Harry S. (*M* 1914), Consulting Engr. (for mail), Leland & Haley, 58 Sutter St., and 735 21st Ave., San Francisco, Calif.

HALL, C. H. (*M* 1927), Chief Engr., Domestic Stoker Co., 7 Dey St., New York, N. Y., and (for mail), 250 Hamilton Ave., Glen Rock, N. J.

HALLEY, Wilson H. (*M* 1925; *J* 1923), Engr., Langenberg Mfg. Co., 4519 N. Euclid Ave., and (for mail) 6134 W. Park Ave., St. Louis, Mo.

HALLIDAY, Leo (*A* 1926), Vice-Pres. and Gen. Mgr. (for mail), Newport Boiler Co., 529 S. Franklin St., and 7242 East End Ave., Chicago, Ill.

HAMJY, Paul W. (*M* 1924), Owner (for mail), Paul W. Hamjy, 1158 Mohawk St., and 612 Steel Pl., Utica, N. Y.

HAMLIN, Harry A. (*A* 1916), Johnson Service Co., 427 Brainard St., Detroit, Mich.

HANCHETT, James H. (*A* 1926), Trane Co., 210 S. Tenth St., Minneapolis, Minn.

HANCOCK, James Reynolds (*A* 1928; *J* 1926), 131 W. Chestnut St., Jeffersonville, Ind.

HANKIN, Richard (*M* 1898), 279 Main Ave., Passaic, N. J.

HANLEY, John H., Jr. (*M* 1923), 1718 East 26th St., Brooklyn, N. Y.

HANSEN, Charles C. (*M* 1928), 428 Prospect St., South Orange, N. J.

HANSON, E. W. (*M* 1922), W. N. Sauer Co., 809 Chestnut St. N., S. Pittsburgh, Pa.

HANSON, Leon C. (*A* 1918), Secy-Treas-Mgr. (for mail), Bjorkman Bros. Co., 712 Tenth St. S., and 4603 Sunnyside Rd., Minneapolis, Minn.

HARBULA, M. G.* (*M* 1921), Consulting Engr. (for mail), 1775 Broadway, New York, and 3512 Brewster Ave., Flushing, N. Y.

HARDING, Louis A. (*M* 1911), (1st Vice-Pres., 1929; 2nd Vice-Pres., 1928; Council, 1922-1929), Pres., L. A. Harding Construction Corp., 1335 Main St., and 85 Cleveland Ave., Buffalo, N. Y.

HARDING, Romie M. (*M* 1928), 151 Broadway, Passaic, N. J.

HARDINGE, Franklin (*A* 1929), Chairman of Board of Directors (for mail), Hardinge Bros., Inc., 4149 Ravenswood Ave., and 1432 Fargo Ave., Chicago, Ill.

HARE, Edgar S. (*M* 1920), W. Hare's Sons Co., 46–14th St., Wheeling, W. Va.

HARMS, William T.* (*M* 1917), Owner of Business, 1015 Vinewood Ave., Detroit, Mich.

HARPER, Samuel H. (*M* 1929; *A* 1927), Prop., Htg. Equipment Co., and (for mail), Dist. Engr., Aerofin Corp., 1945 Oliver Bldg., Pittsburgh, and 223 Dalzell Ave., Ben Avon, Pittsburgh, Pa.

HARRIGAN, Edward M. (*M* 1915), 1365 Baker St., Detroit, Mich.

HARRINGTON, Charles (*M* 1923), 43 Indian Grove, Toronto, Ont., Can.

HARRIS, Henry W. (*A* 1924), 4296 Washington Blvd., St. Louis, Mo.

HARRIS, Jesse Brownell (*M* 1918), Partner (for mail), Rose & Harris, Engrs., 452 N. W. National Life Insurance Bldg., and 3620 Colfax Ave. S., Minneapolis, Minn.

HARRISON, Burt S. (*M* 1918), Chief Engr., Nichols Products Corp., 122 East 42nd St., New York, and (for mail), 148 Clinton St., Brooklyn, N. Y.

HARRISON, James M. (*M* 1919), J. M. Harrison, Inc., Guarantee Title Bldg., Cleveland, Ohio.

HART, Harry M. (*M* 1912), (*Presidential Member*), (Pres., 1916; 1st Vice-Pres., 1915; Council, 1914-1917), Pres., L. H. Prentice Co., 1048-50 Van Buren St., Chicago, Ill.

HART, Thomas H. (*J* 1927), Chief Engr., Buckeye Incubator Co., and (for mail), 1827 Stratford Pl., Springfield, Ohio.

HARTER, B. B. (*J* 1926), Htg. Engr. (for mail), Warren Webster & Co., 549 W. Washington Blvd., Room 506, and 5011½ W. Maypole Ave., Chicago, Ill.

HARTMAN, Frank E.* (*M* 1924), Vice-Pres. and Chief Chemist (for mail), U. S. Ozone Co., 500 N. Dearborn St., and 6435 N. Richmond St., Chicago, Ill.

HARTMAN, John Milton (*M* 1927), Kewanee Boiler Co., Kewanee, Ill.

HARTPENCE, Charles C. (*M* 1923), Htg. & Vtg. Engr., 309 Third National Bank Bldg., and (for mail), P. O. Box 337, Columbus, Ga.

HARTWELL, Joseph C. (*M* 1922), Grinnell Co., Inc., 260 W. Exchange St., Providence, R. I.

HARVEY, Alexander D. (*A* 1928; *J* 1925), Sales Mgr. (for mail), Nash Engrg. Co., S. Norwalk, and New Canaan, Conn.

HARVEY, Lyle C. (*M* 1928), Sales Promotion Mgr. (for mail), Bryant Heater & Mfg. Co., 17825 St. Clair Ave., and 3042 Beckett Rd., Cleveland, Ohio.

HASEY, Charles E. (*M* 1919), Pres., C. E. Hasey Co., 726 Fourth St., Minneapolis, Minn.

HASKELL, Benjamin E. (*M* 1925), Engr., The Fels Co., 42 Union St., Portland, and (for mail), 539 Brighton Ave., Woodfords, Maine.

HASKINS, Arthur L. (*A* 1927), Htg. Dept. (for mail), The Hunting Co., 127 Railroad St., and 46 Glenn Ellyn Way, Rochester, N. Y.

HATTIS, Robert E. (*M* 1926), Consulting Mech. Engr. (for mail), 6 N. Michigan Ave., and 4152 N. Mozart St., Chicago, Ill.

HAUPT, Howard F. (*A* 1929), Salesman, American Radiator Co., 288 W. Water St., and (for mail), 170 Beaumont Ave., Milwaukee, Wis.

HAUSS, Charles F. (*Charter Member*), 931 Prinsengracht, Amsterdam, Holland.

HAWES, Herbert R. (*M* 1926), 22 Elmwood St., Worcester, Mass.

HAYES, James J. (*M* 1920), Sales Engr. (for mail), Standard Power Equipment Co., 926 Monadnock Bldg., and 7443 Jeffery Ave., Chicago, Ill.

HAYES, Joseph G. (*M* 1908), Pres. and Engr. (for mail), Hayes Bros., Inc., 236 W. Vermont St., and 2849 N. Capitol Ave., Indianapolis, Ind.

HAYNES, C. V. (*M* 1917), (Council, 1926-1929), Vice-Pres. and Gen. Mgr., Hoffman Specialty Co., 25 West 45th St., New York, N. Y., and (for mail), 115 Llanfair Rd., Ardmore, Pa.

HAYWARD, Ralph B. (*M* 1909), Pres. (for mail), R. B. Hayward Co., 1714 Sheffield Ave., Chicago, and 201 S. Stone Ave., La Grange, Ill.

HEAGERTY, William H. (*A* 1923), Vice-Pres. and Gen. Mgr., Oil City Boiler Works, Oil City, Pa.

HEAGLER, John M. (*M* 1922), Htg. and Vtg. Engr., American Foundry & Furnace Co., 809 Guardian Bldg., and (for mail), 1646 Iglehart Ave., St. Paul, Minn.

HEATH, Frederick R. (*M* 1913), 89 Trowbridge St., Cambridge, Mass.

HEATH, Samuel C. (*A* 1928), 2345–31st Ave. S., Seattle, Wash.

HEATHERTON, James M. (*A* 1904), Plumbers' Trade Journal, 239 West 30th St., New York, N. Y.

HECK, George L., Jr. (*A* 1921), Chief Engr. (for mail), Garden City Fan Co., 1842 McCormick Bldg., and 8112 Ellis Ave., Chicago, Ill.

HECKEL, E. P. (*M* 1918), Vice-Pres. (for mail), Carrier Engrg. Corp., 1032 Burnham Bldg., Chicago, and 314 Cuttriss Pl., Park Ridge, Ill.

HECKROTH, Harry H. (*A* 1929), Eastern Sales Mgr., Banner Rock Products Co., Alexandria, Ind., and (for mail), 1322 Locust St., Philadelphia, Pa.

HEDGES, H. Berkley (*M* 1919), Dist. Mgr. (for mail), York Htg. & Vtg. Corp., 149 Broadway, New York, N. Y., and 1021 Park Lane, Plainfield, N. J.

HEDLEY, Park S. (*M* 1923), (for mail), Hedley & Voisinet, 374 Delaware Ave., Buffalo, and 31 Westgate Rd., Kenmore, N. Y.

HEEBNER, Walter M. (*M* 1922), Sales Engr., Warren Webster & Co., 470 Fourth Ave., New York, N. Y., and (for mail), 362 Highwood Ave., Teaneck, N. J.

HEIDENREICH, George (*M* 1928), C. A. Dunham Co., 506 Board of Trade Bldg., Indianapolis, Ind.

HEILES, F. C. (*M* 1920; *J* 1914), c/o Perry West, 13 Central Ave., Newark, N. J.

HEILMAN, Russell H.* (*M* 1923), Mellon Institute, Pittsburgh, Pa.

HEINLE, E. L. (*M* 1920), Secy-Treas. (for mail), The Kain-Petersen-Heinle Co., 437 East 106th St., Cleveland, and 3350 Tullamore Rd., Cleveland Heights, Ohio.

HELBURN, I. B. (*M* 1929; *J* 1927), Asst. Sales Mgr. (for mail), Circulair Heat, Inc., 215 Central Ave., and 1440 S. Fourth St., Louisville, Ky.

HELLERMAN, Harry H. (*M* 1902), The Penn Engrg. Co., 312 Cherry St., Philadelphia, Pa.

HELLSTROM, John (*A* 1929), Gen. Mgr., Midwest Corp., Bradford, Pa.

HELPHINGSTEIN, Otto (*M* 1919), Pres. and Mgr., The Cullyford Co., 1600 Monroe St., Amarillo, Tex.

HELSTROM, Herman G. (*M* 1928), (for mail), Kewanee Boiler Corp., 708 Builders Exchange, and 4608 Arden Ave., Minneapolis, Minn.

HELWIG, Gunther Albert (*M* 1927), Prop., National Htg. & Vtg. Co., 920 Cass Ave., and 4217 Athlone Ave., St. Louis, Mo.

HEMINGWAY, William S. (*M* 1906), 3210 Mountain View Dr., San Diego, Calif.

HENION, Hudson D. (*A* 1923), Sales Mgr. (for mail), C. A. Dunham Co., Ltd., 1523 Davenport Rd., and 45 Ridge Dr., Toronto, Ont., Can.

HENNINGS, William A. (*M* 1926), Sales Engr. and Estimator, W. F. Thumm, Inc., 1130 Cornelia Ave., and (for mail), 1445 Summerdale Ave., Chicago, Ill.

HENRICH, George A. (*M* 1914), Marcellus, Mich.

HENRICI, Herman C. (*M* 1914), Pres., Henrici Lowry Engrg. Co., 508 Huntzinger Bldg., 114 W. Tenth St., and (for mail), 430 West 58th St., Kansas City, Mo.

HERENDEEN, Frederick W. (*M* 1920), Secy. (for mail), The Institute of Boiler and Radiator Mfrs., 29 Seneca St., and 815 S. Main St., Geneva, N. Y.

HERLIHY, George F. (*M* 1922), Vice-Pres. (for mail), J. J. Herlihy, Inc., 810 W. Congress St., and 10836 Forest Ave., Chicago, Ill.

HERLIHY, Jeremiah J. (*Life Member; M* 1914), Pres., J. J. Herlihy, Inc., 810 W. Congress St., Chicago, Ill.

HERMAN, Harry H. (*A* 1927; *J* 1925), Warren Webster Co., 1226 California St., Denver, Colo.

HEROLD, Charles W. (*A* 1928), Sole Owner (for mail), Herold Plbg. & Htg. Co., 1315 East 26th St., and 2600 Pasco, Kansas City, Mo.

HERRICK, Daniel A. (*M* 1923), Julian D'Este Co., 2 Spice St., Charlestown, Mass.

HERRING, Edgar (*M* 1919), Chairman (for mail), I. Jeffreys & Co., Ltd., Barrons Pl., Waterloo Rd., and 22 Keswick Rd., Putney, London, S. W., England.

HERSH, G. Willis (*M* 1917), 2510 Chew St., Allentown, Pa.

HERTZ, H. P. (*M* 1924), Engr. (for mail), Routledge & Hertz, Architects and Engrs., 204 Exchange National Bk., and 314 Twelfth Ave., E., Hutchinson, Kans.

HERTZLER, John R. (*J* 1928), (for mail), Air Conditioning Dept., York Ice Machinery Corp., Yorkco Club, York, and 627 N. Duke St., Lancaster, Pa.

HESS, Horace L. (*M* 1924), 214 Nedro Ave., Olney, Philadelphia, Pa.

HESTER, Thomas J. (*M* 1919), Vice-Pres. and Treas. (for mail), Hester Bradley Co., 4200 Forest Park Blvd., and 67 Aberdeen Pl., St. Louis, Mo.

HETTINGER, Henry (*A* 1927), 40 Rose Ave., Floral Park, L. I., N. Y.

HEYDON, Charles G. (*A* 1923), Mgr., Sales Western Div., Wright Austin Co., 315 Woodbridge St. W., and (for mail), 2681 Nebraska St., Detroit, Mich.

HIBBS, Frank C. (*M* 1917), Salesman, The H. B. Smith Co., 2209 Chestnut St., and (for mail), 846 North 65th St., Philadelphia, Pa.

HIERS, Charles R. (*M* 1929; *A* 1929; *J* 1927), 294 Sherburne Ave., St. Paul, Minn.

HIGGINS, Dan T. (*M* 1928), McCarthy-Crandall, Inc., 529 S. Cascade Ave., Colorado Springs, Colo.

HIGGINS, Thomas J. (*M* 1927; *A* 1927; *J* 1923), Vice-Pres. (for mail), Ross Engrg. Co. of Canada, Ltd., New Birks Bldg., Montreal, and 478 Victoria Ave., Westmount, P. Q., Can.

HILL, E. G. T. (*M* 1922), 20 Vermont Crescent, Newland Hill, E. Yorke, England.

HILL, E. Vernon* (*M* 1914; *A* 1912), (*Presidential Member*), (1st Vice-Pres., 1919; 2nd Vice-Pres., 1918; Council, 1915-1921), Pres. (for mail), E. Vernon Hill Co., 121 N. Clark St., and 1126 Farwell Ave., Chicago, Ill.

HILL, Newell J. (*M* 1916), Consulting Engr. (for mail), 708 Architects Bldg., and 19567 Stratford Rd., Detroit, Mich.

HILLEN, A. G. (*J* 1929), Engr., Carrier Engrg. Corp., 1032 Burnham Bldg., Chicago, Ill.

HILLEN, William G. (*A* 1929), 102 N. Walnut St., East. Orange, N. J.

HILLIARD, Charles E. (*J* 1927), Htg. and Vtg. Engr. (for mail), 27 B St., S. Boston, and 1301 Washington St., S. Braintree, Mass.

HILLS, Arthur H. (*M* 1924), C. A. Dunham Co., 101 Park Ave., New York, N. Y.

HINCHMAN, E. G. (*M* 1923), 1263 Atlantic Ave., Brooklyn, N. Y.

HINKLE, Edwin C. (*M* 1911), 170 Franklin St., Hempstead, N. Y.

HINRICHSEN, A. F. (*M* 1928), Pres. (for mail), A. F. Hinrichsen, Inc., 50 Church St., New York, N. Y., and Mountain Lakes, N. J.

HIRES, J. Edgar (*M* 1927), Consulting Engr., 2025 Fidelity-Philadelphia Bldg., Philadelphia, and (for mail), 107 Linwood Ave., Ardmore, Pa.

HIRSCHMAN, William F. (*M* 1929), Pres. and Treas., W. F. Hirschman Co., Inc., 220 Delaware Ave., and (for mail), 1380 Amherst St., Buffalo, N. Y.

HIRST, James Noble (*J* 1927), Chief Draftsman (for mail), York Htg. & Vtg. Corp., 1541 Sansom St., and 2913 Poplar St., Philadelphia, Pa.

HITCHCOCK, Frederick P. (*M* 1917), Sales Repr. (for mail), Herman Nelson Corp., 309 Lathrop Bldg., and 4938 Forest Ave., Kansas City, Mo.

HOBBS, J. Clarence (*M* 1920), 60 Wood St., Painesville, O.

HOCHULI, Henry W. (*M* 1925), Sales Engr., Richardson & Boynton Co., 260 Fifth Ave., New York, N. Y., and (for mail), 113 Chester Ave., Bloomfield, N. J.

HODGDON, Harry A. (*M* 1919), 153 Norfolk St., Wollaston, Mass.

HOERSTING, Frank J. (*M* 1921), Pres. (for mail), The Hoersting & Holtmann Co., 1130 W. Third St., and 2045 Philadelphia Dr., Dayton, O.

HOFFMAN, Charles S. (*M* 1924), Baker Smith & Co., Inc., 576 Greenwich St., New York, N. Y.

HOFFMAN, George D. (*M* 1906), Pres., Hoffman Specialty Co., Inc., Waterbury, Conn., and (for mail), Box 240, Pasadena, Calif.

HOFFMAN, James D. (*M* 1903), (*Presidential Member*), (Pres., 1910; 1st Vice-Pres., 1908; Board of Governors, 1911-1912), Prof. of Practical Mechanics, Head of Dept., Director of Practical Mech. Lab. (for mail), Purdue University, and 323 University St., W. Lafayette, Ind.

HOFT, Paul J. (*M* 1925; *A* 1924), Prop. (for mail), Paul J. Hoft Plbg. & Htg. Co., 245 S. Eighth St., and 1119 Wyoming Ave., Philadelphia, Pa.

HOGABOOM, Henry Raymond (*M* 1929), Pres. & Treas. (for mail), Hogaboom Htg. & Vtg. Co., 202 Kulien Bldg., and 1529–33rd Ave., Seattle, Wash.

HOGAN, Edward L. (*M* 1911), Consulting Engr. (for mail), American Blower Corp., 6000 Russell St., and 700 Seward Ave., Detroit, Mich.

HOIER, William V. (*M* 1917), Wm. V. Hoier Co., 701 N. Wells St., Chicago, Ill.

HOLBROOK, Frank M.* (*M* 1923), 84 Park St., Montclair, N. J.

HOLMBERG, John A. (*M* 1924), 122 E. Lincoln, Lindsborg, Kans.

HOLTON, John H. (*M* 1927), Director of Research (for mail), York Htg. & Vtg. Corp., Bridgeport, Montgomery Co., Pa., and 1718 Williams Way, Norristown, Pa.

HONIBALL, Charles R.* (*M* 1911), 156 Boundary St., Liverpool, England.

HOOD, O. P. (*Honorary Member* 1929), Chief Mech. Engr., U. S. Bureau of Mines, Washington, D. C.

HOOK, C. Howard (*M* 1915), Pres. (for mail), Hook Heater Co., Sharpesburg P. O. Sta., Pittsburgh, and 6949 Thomas Blvd., Pittsburgh, Pa.

HOOK, Maurice G. (*M* 1919), C. A. Dunham Co., 101 Park Ave., New York, N. Y.

HOOVER, H. Earl (*A* 1922), The Hoover Co., 2300 Willoughby Tower, Chicago, Ill.

HOPKIN, William E. (*M* 1919), Pres. and Treas. (for mail), Charles E. Hopkin Co., 107 Bethlehem Pike, and 514 Wyndmoor Ave., Chestnut Hill, Philadelphia, Pa.

HOPSON, William T. (*M* 1915), The Hopson & Chapin Mfg. Co., New London, Conn.

HORNUNG, John C. (*M* 1914), Engr. (for mail), Central Heat Appliances, 343 S. Dearborn St., Chicago, and 854 Bluff St., Glencoe, Ill.

HORTON, Homer F. (*M* 1925), Sales Repr. (for mail), 2301 Knox Ave., Chicago, and 343 Green Bay Rd., Glencoe, Ill.

HOSTERMAN, Charles O. (*M* 1924), 25 Bales Rd., Dorchester, Mass.

HOTCHKISS, Charles H. B. (*M* 1927), Asst. Prof. of Htg. and Vtg., Purdue University, Lafayette, Ind.

HOUGHTEN, Ferry C.* (*M* 1921), Research Lab., A. S. H. V. E., U. S. Bureau of Mines 4800 Forbes St., Pittsburgh, Pa.

HOULISTON, George Baillie (*A* 1928), Sales Engr. (for mail), Warren Webster & Co., 919 Provident Bk. Bldg., Cincinnati, O., and 33 Tower Pl., Ft. Thomas, Ky.

HOUPT, George A. (*M* 1916), Philadelphia Piping & Equipment Co., 1605 Rockland St., Philadelphia, Pa.

HOWATT, John* (*M* 1915), (Council, 1927-1929), (for mail), Board of Education, 188 W. Randolph St., and 6720 Merrill Ave., Chicago, Ill.

HOWE, Willis W. (*A* 1917), (for mail), American Radiator Co., 816 S. Michigan Ave., and 5502 Everett Ave., Chicago, Ill.

HOWELL, Frank B. (*M* 1920), American Radiator Co., 40 West 40th St., 20th Floor, New York, N. Y.

HOWELL, Lloyd (*M* 1915), Mgr., Canadian Sirocco Co., Ltd., Windsor, Ont., Can.

HOYT, William B.* (*M* 1919), Pres. and Treas. (for mail), The Hoyt-Grant Co., 52 Whitney Ave., New Haven, and 39 Clifford St., Whitneyville, Conn.

HUBBARD, Allen (*M* 1919), Consulting Engr., Hollis French & Allen Hubbard, 210 South St., Boston, Mass.

HUBBARD, Allen, Jr. (*M* 1929), Engr., Hollis French & Allen Hubbard, 210 South St., Boston, Mass.

HUBBARD, George Wallace* (*M* 1911), Chief Mech. Engr. (for mail), Graham, Anderson, Probst & White, 1417 Railway Exchange, Chicago, and 710 Bonnie Brae, River Forest, Ill.

HUBBARD, Nelson B. (*M* 1919), Consulting Engr. (for mail), Room 500, 1346 Broadway, and 2985 Blaine Ave., Detroit, Mich.

HUCH, A. J. (*M* 1919), Gen. Mgr. of Sales (for mail), Central Supply Co., 312 S. Third St., and 4037 Harriet Ave., Minneapolis, Minn.

HUCKEL, Frank, Jr. (*M* 1920), 120 South 30th St., Philadelphia, Pa.

HUCKER, Joseph H. (*M* 1921), 715 Stanbridge St., Norristown, Pa.

HUGHES, Willard C. (*M* 1921), Pres. (for mail), Wicks-Hughes & Co., 224 Genesee St., and 16 Cottage Pl., Utica, N. Y.

HUMPHREY, Dwight E.* (*M* 1921), Goodyear Tyre & Rubber Co., Akron, O.

HUMPHREYS, A. E. (*M* 1911), Mgr., O'Mara Htg. Co., 504 Victoria Bldg., St. Louis, Mo.

HUNGER, Robert F. (*M* 1927), Davidson & Hunger, 1302 Land Title Bldg., Philadelphia, Pa.

HUNT, Phil M. (*M* 1922), Sales Engr., Hoffman Specialty Co., 557 Market St., and (for mail), 1245 Francisco St., San Francisco, Calif.

HUNT, Richard B. (*M* 1912), Sales Engr., 414 S. Fourth Ave., Mt. Vernon, N. Y.

HUNTER, Charles C. (*A* 1923), 90 North 17th St., East Orange, N. J.

HURLEY, Joseph C. (*M* 1915), Petroleum Fuel Engrg. Co., 4028-32 Filbert St., Philadelphia, Pa.

HUSBAND, Edward Woods (*M* 1922), Draftsman, Public Buildings Dept., City Hall, and (for mail), 114 Corinth St., Providence, R. I.

HUTTON, William (*M* 1919), Pres. (for mail), The Hutton Bros. Co., 9 Union St., and 28 Spring St., Winsted, Conn.

HUTZEL, A. F. (*M* 1916), Partner (for mail), Hutzel & Co., 119 E. Washington St., and 2115 Wallingford Rd., Ann Arbor, Mich.

HUTZEL, Hugo F. (*M* 1918), 64 N. Long St., Williamsville, N. Y.

HUTZEL, Max H. (*M* 1923), Hutzel Bldg., Muncie, Ind.

HUTZEL, Victor C. (*M* 1923), Hutzel & Co., Hutzel Bldg., Muncie, Ind.

HUZZARD, Edward C. (*A* 1924), 710 New Holland Ave., Lancaster, Pa.

HYMAN, Wallace M. (*M* 1920), Vice-Pres. (for mail), Reis & O'Donovan, Inc., 255 West 28th St., and 210 West 70th St., New York, N. Y.

HYNES, Lee P.* (*M* 1919), Elec. Engr. (for mail), 30 Church St., New York, and Delmar, N. Y.

I

ICKERINGILL, John (*M* 1923), Spencer Heater Co., 16th and Sansom Sts., Philadelphia, Pa.

ILLIG, Walter R. (*A* 1927), Mgr., Plbg. Dept., The Jennison Co., 17 Putnum St., and (for mail), 37 Allston Pl., Firchburg, Mass.

IMPEY, Paul F. (*A* 1925; *J* 1921), Htg. Engr., 2623–78th Ave., Elmwood Park, Cragin P. O., Chicago, Ill.

INGALLS, F. D. B. (*M* 1906), Htg. and Sales Engr., 136 Federal St., Boston, and (for mail), 1 Hopkins St., Reading, Mass.

INGELS, Margaret* (*M* 1923; *J* 1918), 336 Linden Walk, Lexington, Ky.

INNIS, Helen R.* (*M* 1921; *J* 1918), Largent, W. Va.

ISSERTELL, Henry G.* (*M* 1913; *A* 1912), Commercial Engr. (for mail), General Elec. Co., 120 Broadway, and 825 West 180th St., New York, N. Y.

J

JACKSON, Charles H. (*M* 1923), Sales Engr. (for mail), Bayley Blower Co., 732 Greenbush St., and 614 Farwell Ave., Milwaukee, Wis.

JACKSON, Charles J. (*A* 1912), Vice-Pres., Jenkins Bros., 646 Washington Blvd., Chicago, Ill.

JACKSON, George O. (*A* 1928), Pres. (for mail), Jackson Engrg Co., 39 S. Capitol Ave., and 124 East 44th St., Indianapolis, Ind.

JACKSON, J. O. (*A* 1928), Jackson Supply Co., 333 W. Ohio St., Indianapolis, Ind.

JACKSON, Jonathan William (*A* 1927), Pierce Co., 41-43 W. Spring St., Gainesville, Ga.

JACKSON, Marshall S. (*M* 1919), Repr. (for mail), Powers Regulator Co., 232 Delaware Ave., and 108 Larchmont Rd., Buffalo, N. Y.

JACOBS, Barrett (*A* 1928), Pres. (for mail), Jacobs Htg. Corp., 122 East 42nd St., and 255 Haven Ave., New York, N. Y.

JACOBUS, Dr. David S. (*M* 1916), Advisory Engr., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.

JALIEN, John J. (*M* 1922), 320 Central Park, W., New York, N. Y.

JANET, Harry L. (*M* 1920), Engr. (for mail), Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, N. J., and 688 Decatur St., Brooklyn, N. Y.

JARDINE, Douglas C. (*M* 1929; *A* 1926), Partner (for mail), Jardine & Knight Plbg. & Htg. Co., 312 Custer Ave., and 1731 N. Nevada Ave., Colorado Springs, Colo.

JAYNES, Eubertis L. (*M* 1918), Pres. (for mail), Michigan Warming & Vtg. Co., 363 Houseman Bldg., and 862 Ardmore St. S. E., Grand Rapids, Mich.

JELLETT, Stewart A. (*Honorary Member* 1929), (*Charter Member; Presidential Member*), (Pres., 1895; Board of Mgrs., 1896-1899; Secy., 1898), Pres. (for mail), Stewart A. Jellett Co., 1200 Locust St., Philadelphia, and 6701 Lincoln Dr., Mt. Airy, Philadelphia, Pa.

JENKINS, Harry E. (*A* 1923), Sales Mgr., Radiator Div. (for mail), Winchester Repeating Arms Co., and 436 Whalley Ave., New Haven, Conn.

JENNINGS, Irving C. (*M* 1924), Nash Engrg. Co., S. Norwalk, Conn.

JENNINS, Henry H. (*M* 1901), 15 Grange View, Chapeltown Rd., Leeds, England.

JENSON, Jean S. (*M* 1912), 431 S. Dearborn St., Chicago, Ill.

JOHN, Benjamin F. (*M* 1920), 1003 Race St., Philadelphia, Pa.

JOHNS, Harold B. (*M* 1928; *J* 1927), Mgr., House Htg. Div. (for mail), Peoples Gas Co., 122 S. Michigan Ave., Chicago, and 543 N. Elmwood Ave., Oak Park, Ill.

JOHNSEN, Henry (*M* 1927), Plbg. and Htg. Contractor, 173 Jewett Ave., Port Richmond, and (for mail), 70 Emerson Ave., Dongan Hills, S. I., N. Y.

JOHNSON, Carl W. (*M* 1912), Pres. (for mail), C. W. Johnson, Inc., 211 N. Desplaines St., and 1809 Morse Ave., Chicago, Ill.

JOHNSON, Donald H. (*J* 1927), C. A. Dunham Co., 450 E. Ohio St., Chicago, Ill.

JOHNSON, Edgar E. (*M* 1926), Sales Engr. (for mail), Buffalo Forge Co., 490 Broadway, and 200 Loring Ave., Buffalo, N. Y.

JOHNSON, Edward B. (*M* 1919), Sales Engr., Staten Island Supply Co., 1390 Richmond Ter., and (for mail), 154 Wardwell Ave., W. New Brighton, S. I., N. Y.

JOHNSON, Fred W. (*M* 1916), 6530 Beaubein St., Detroit, Mich.

JOHNSON, Helge S. (*J* 1927), Sales Engr. (for mail), The Coon-DeVisser Co., 2051 W. Lafayette Blvd., and 156 W. Margaret St., Detroit, Mich.

JOHNSON, James M. (*A* 1928), 825 North 24th St., Philadelphia, Pa.

JOHNSON, Ralph B. (*M* 1922), 1100 E. Douglas Ave., Wichita, Kans.

JOHNSON, Royster H. (*M* 1927), 660 College St., Jacksonville, Fla.

JOHNSON, Tracy R. (*M* 1924), Mgr., Htg. Specialties Dept., The Trane Co., and (for mail), 628 S. Fourth St., Apt. 2, La Crosse, Wis.

JOHNSON, Walter F. (*M* 1929), 374 Delaware Ave., Buffalo, N. Y.

JOHNSTON, James A. (*M* 1912), Member (for mail), Carneal, & Johnston, 806 Va. Ry. & Power Bldg., Richmond, Va.

JOHNSTON, Robert Elliott (*A* 1926), Consulting Engr., 3342–33rd Ave., W., Vancouver, B. C.

JOHNSTON, William B. (*M* 1921; *A* 1916), Vice-Pres. (for mail), Ideal Furnace Co., 2995 E. Grand Blvd., and 19450 Gloucester Dr., Palmer Woods, Detroit, Mich.

JOHNSTON, William H. (*M* 1924), Pres. (for mail), Johnston Htg. Co., 332 East 47th St., New York, and Larchmont, N. Y.

JONES, Alfred (*M* 1928), Director of Research (for mail), Armstrong Cork Co., Research Div., P. O. Box 565, and 402 President Ave., Lancaster, Pa.

JONES, Alfred L. (*M* 1926), Supt. of Htg., Alfred Penovi & Sons, 89 Railroad Ave., Greenwich, and (for mail), Breezmont Ave., Riverside, Conn.

JONES, Bernard G. (*M* 1928), Acme Elec. Co., Ltd., 148 Princess St., Winnipeg, Manitoba, Can.

JONES, Charles R. (*M* 1928), Mgr., Jones Supply Co., 917-921 St. Nicholis Ave., Siloam Springs, Ark.

JONES, Edwin (*J* 1924), Box 382, Tulsa, Okla.

JONES, Edwin A. (*M* 1919), Mgr., Gas Div. (for mail), L. J. Mueller Furnace Co., 197 Reed St., and 2564 Bay Ridge Ave., Milwaukee, Wis.

JONES, Edwin F. (*M* 1923), Consulting Engr. (for mail), 116 E. Fourth St., and 1954 Grand Ave., St. Paul, Minn.

JONES, Ernest (*A* 1923), Dist. Mgr. (for mail), B. F. Sturtevant Co., 423 Dwight Bldg., and 4502 Mill Creek Pkwy., Kansas City, Mo.

JONES, Ernest F. (*M* 1923), 1243 Morse Ave., Chicago, Ill.

JONES, Harold L. (*M* 1920), W. W. Farrier Co., 44 Montgomery St., Jersey City, N. J.

JONES, Louis T. (*M* 1921), 3700 Highland Ave., Drexel Hill, Delaware Co., Pa.

JONES, Morris P. (*A* 1925), Mgr., Fan Sales Div., New York Blower Co., 3155 Shields Ave., and (for mail), 5430 Crystal St., Chicago, Ill.

JONES, Raymond E. (*M* 1919), Pres., Haynes Selling Co., Inc., 2013 Sansom St., Philadelphia, Pa., and (for mail), 39 West End Ave., Haddonfield, N. J.

JONES, W. T. (*M* 1915), (Council, 1925-1929), Barnes & Jones, 128 Brookside Ave., Jamaica Plains, Boston, Mass.

JUNG, John S. (*A* 1923), 834 Layton Blvd., Milwaukee, Wis.

JUNKERS, Prof. Hugo (*M* 1925), Junkers-Werke, and (for mail), Kaiserplatz 21, Dessau, Germany.

JUTTNER, Otto J. (*M* 1915), Pres. (for mail), Juttner Htg. Co., 432 Jefferson St., and Elks Club, Milwaukee, Wis.

K

KAMMAN, Arnold R. (*A* 1925; *J* 1921), (for mail), John W. Danforth Co., 72 Ellicott St., Buffalo, and 3 E. Pkwy., Wanakah, Erie Co., N. Y.

KAMMERER, W. C. (*M* 1923), Mech. Engr. (for mail), Hadlow, Hughes, Hick & Conrad, Inc., 1301 Citizens Bldg., Cleveland, and 13903 Clifton Blvd., Lakewood, Ohio.

KAPPEL, George W. A. (*M* 1921), Camden Htg. Co., 8 Market St., Camden, N. J.

KAPPLER, Herman C. (*M* 1927), York Htg. & Vtg. Corp., 10th and Sansom Sts., Philadelphia, Pa.

KARLSON, Alfred F. (*M* 1918), Chief Engr. (for mail), Parks-Cramer Co., 970 Main St., Fitchburg, and 186 Prospect St., N. Leominster, Mass.

KASTELLO, August (*M* 1923), Mgr. of Branch No. 4 (for mail), C. A. Dunham Co., Ltd., 409 New Birks Bldg., and 112 Cornwall Ave., Town of Mt. Royal, Montreal, P. Q., Can.

KATSUMOTO, Kijiro (*M* 1920), Pres. (for mail), Katsumoto & Co., 30 Awaji-cho, and 3 Kitaichi macho, Dairen, S. Manchuria, China.

KAUFFMAN, Rufus (*M* 1921), 4108 N. Broad St., Philadelphia, Pa.

KAYSING, Harry C. (*M* 1920), 4200 Forest Park Blvd., St. Louis, Mo.

KEASBEY, A. P. (*M* 1922), Pres. and Gen. Mgr. (for mail), Robert A. Keasbey Co., 115 West St., New York, N. Y., and 298 Park St., Montclair, N. J.

KEENAN, P. Frank (*A* 1921), Pres. (for mail), Leo Flush Valve Co., 331 Madison Ave., New York, and 288 Burns St., Forest Hills, L. I., N. Y.

KEENEY, Frank P. (*A* 1919), Pres., Domestic Engrg., 1900 Prairie Ave., Chicago, Ill.

KEHM, August (*M* 1901), (1st Vice-Pres., 1909, Board of Governors 1908-1911), Pres. (for mail), Kehm Bros. Co., 51 E. Grand Ave., and 1300 N. Dearborn Ave., Chicago, Ill.

KEHM, Horace Stevens (*M* 1928), Contractor (for mail), Kehm Bros. Co., 51 E. Grand Ave., and 2337 Commonwealth Ave., Chicago, Ill.

KELBLE, Frank R. (*M* 1928), Mgr. and Htg. Engr. (for mail), The Huffman-Wolfe Co., 11 W. Rittenhouse St., Philadelphia, and Box A-34, Glenside, Pa.

KELLEY, James J. (*A* 1924), 333 Commonwealth Ave., Boston, Mass.

KELLOGG, Alfred (*M* 1916), (Council, 1920-1921; 1923-1924), Consulting Engr. (for mail), 383 Boylston St., Boston, and 6 Hawthorne St., Belmont, Mass.

KELLOGG, H. D. (*Life Member; A* 1916), Haverford, Pa.

KELLOGG, Thomas M. (*M* 1929; *A* 1923), Bishop & Babcock Co., 444 Lafayette St., New York, N. Y.

KELLY, Hugh (*M* 1927), 10041-101 A Ave., Edmonton, Alberta, Can.

KELLY, John G. (*A* 1919), 374 Park Ave., Yonkers, N. Y.

KENT, James King (*J* 1928), Secy-Treas. (for mail), Nu Heat Corp., 210 Chestnut St., and 1030 Commodore Dr., St. Louis, Mo.

KENT, Laurence F. (*A* 1927; *J* 1924), Moncrief Furnace Co., P. O. Box 1073, Atlanta, Ga.

KEPLINGER, William L. (*M* 1929), Dist. Mgr. (for mail), Aerofin Corp., 11 West 42nd St., New York, and 140 Fulton Ave., Hempstead, L. I., N. Y.

KERN, Raymond T. (*M* 1927), Chief Engr., Jennison Co., Fitchburg, and (for mail), 51 Claflin St., Leominster, Mass.

KERNEY, Thomas F. (*J* 1925), Engr., H. Berkeley Hackett, 1001 Public Ledger Bldg., and (for mail), 1522 N. Reese St., Philadelphia, Pa.

KERSHAW, Melville G. (*A* 1926; *J* 1921), Dupont Engrg. Co., Wilmington, Del.

KERSJES, William (*M* 1922), 728 Clinton St., Kalamazoo, Mich.

KEYS, George Walter (*A* 1927), 318 Van Kirk St., Crescentville, Philadelphia, Pa.

KEYES, Robert E. (*M* 1913), The Cooling & Air Conditioning Corp., 11 West 42nd St., New York, N. Y.

KIEFER, Carl J. (*M* 1922), Consulting Engr., 901 Schmidt Bldg., Cincinnati, Ohio.

KIEFER, E. J., Jr. (*J* 1928), Mgr. (for mail), H. C. Archibald Co., 8 S. Sixth St., and 108 N. Sixth St., Stroudsburg, Pa.

KIEWITZ, Arthur A. (*M* 1912), 23-80 28th St., Astoria, L. I., N. Y.

KIEWITZ, Conway (*M* 1907), Engr., New York Board of Education, Flatbush Ave. Ext. and Concord St., Brooklyn, and (for mail), 70 King St., Floral Park, L. I., N. Y.

KILBY, Roger E. (*M* 1920), Northwestern Htg. and Plbg. Co., 1105 Sherman Ave., Evanston, Ill.

KILLIAN, Maurice A. (*M* 1929), Glanz & Killian Co., 1761 Forest Ave. W., Detroit, Mich.

KILNER, John Saunders (*M* 1929), Partner (for mail), Kilner-Mills Co., 4-206 General Motors Bldg., and 1091 Seminole Ave., Detroit, Mich.

KIMBALL, Charles W. (*M* 1915), Richard D. Kimball Co., 6 Beacon St., Boston, Mass.

KIMBALL, Dwight D. (*M* 1908), (*Presidential Member*), (Pres., 1915, 2nd Vice-Pres., 1914; Board of Governors 1912-1916), Consulting Engr. (for mail), Kimball & Cucel, 205 East 42nd St., New York, and 330 23rd St., Jackson Heights, L. I., N. Y.

KING, Thomson* (*M* 1923), The Peerless Heater Co., Boyertown, Pa.

KINGSLEY, Edwin A. (*M* 1926), Consulting Engr. (for mail), 101 Park Ave., New York, and 255 Forest Ave., Larchmont, N. Y.

KINNER, J. E. (*M* 1924), 13409 Forest Hill Ave., Cleveland, O.

KIPE, J. Morgan (*M* 1919), Br. Mgr. (for mail), Spencer Heater Co., 609 Otis Bldg., Philadelphia, and Williamsport, Pa.

KIRK, Charles D. (*M* 1909), Mgr., Chas. D. Kirk & Co., Cor. Sargent and Colleen Sts., Winnipeg, Manitoba, Can.

KIRK, George H. (*Life Member;*) (*M* 1906), 6711 Wentworth Ave., Chicago, Ill.

KIRK, Leonard G. (*M* 1923), 441 West 50th St., New York, N. Y.

KIRMES, Edwin W. (*M* 1923), Vice-Pres. and Chief. Engr., Walworth-English-Flett Co., 81 Commercial Wharf, Boston, and (for mail), 29 Oakland St., Melrose, Mass.

KISSICK, J. J. (*M* 1918), (Council, 1927-1928), 1768 Wayside Rd., Cleveland, Ohio.

KITAURA, Shigeyuki (*M* 1918), Monoply Bureau, Dept. of Finance, Tokyo, Japan.

KITCH, Stanley B. (*M* 1928; *A* 1928; *J* 1925), Sales Engr., The Trane Co., 844 Rush St., Chicago, and (for mail), 3330 Wesley Ave., Berwyn, Ill.

KITCHELL, Herbert N. (*A* 1926), Mgr. Htg. Dept. (for mail), Crane Co., 824 Broadway, and 4528 Circle Ave., Cincinnati, O.

KITCHEN, Francis A. (*A* 1927; *J* 1923), J. H. Kitchen & Co., 1012 Pioneer Trust Bldg., Kansas City, Mo.

KITCHEN, John H. (*M* 1906), (for mail), John H. Kitchen & Co., 1016 Baltimore Ave., and 5015 Westwood Ter., Kansas City, Mo.

KLEIN, Albert (*M* 1920), Engr. (for mail), Carrier Lufttechnische Gesellschaft, Langestrasse 63, and Panoramastr. 23, Stuttgart, Germany.

KLEIN, Edward W. (*M* 1917), Dist. Mgr. (for mail), Warren Webster & Co., 152 Nassau St. N. W., and 825 Myrtle St. N. E., Atlanta, Ga.

KLIE, Walter (*M* 1915), Pres. and Treas. (for mail), The Smith & Oby Co., 6107 Carnegie Ave., and 18411 S. Woodland Ave., Cleveland, O.

KLONOWER, Arthur A. (*M* 1920), J. S. Cassedy Co., 132 Austin St., Cambridge, Mass.

KLOTZ, Albert William (*A* 1927), (for mail), 1103 W. Mountain Ave., South Williamsport, Pa.

KLUBE, John O. (*J* 1929), Carrier Engrg. Corp., Newark, and (for mail), 150 Elmora Ave., Elizabeth, N. J.

KNAB, Edward A. (*A* 1927), Htg. Contractor, 1575 Cramer St., Milwaukee, Wis.

KNIGHT, A. Bruce (*A* 1916), Mgr. (for mail), Warren Webster & Co., 7402 Woodward Ave., and 19501 Burlington Dr., Detroit, Mich.

KNOWLES, Arthur F. (*A* 1914), Pres. (for mail), Knowles Mushroom Ventilator Co., 202 Franklin St., New York, N. Y., and 135 Haddon Pl., Upper Montclair, N. J.

KOCH, Harry O. (*M* 1916), 1505 Race St., Philadelphia, Pa.

KOETZ, Lester (*J* 1929), 2505 Elisha Ave., Zion, Ill.

KOHR, Raymond K. (*A* 1928; *J* 1927), 3631 Westfield Ave., Camden, N. J.

KOITHAN, William S. (*M* 1913), Koithan & Pryor, 39 Cortlandt St., New York, N. Y.

KORN, Charles B. (*M* 1922), 1022 S. Eighth St., Allentown, Pa.

KOTTCAMP, Horace A. (*M* 1915), Cor. Philadelphia Ave. and Kenwood Rd., Chambersburg, Pa.

KRATZ, Alonzo P.* (*M* 1925), Research Prof. (for mail), Dept. of Mech. Engrg., University of Illinois, and 1003 Douglas Ave., Urbana, Ill.

KREISSL,, Hans George (*M* 1925), American Radiator Co., 816 S. Michigan Ave., Chicago, Ill.

KREITNER, William (*J* 1926), Engr., Modine Mfg. Co., 101 Park Ave., New York, and (for mail), 108 Linden St., Brooklyn, N. Y.

KRIEBEL, Arthur E. (*M* 1920), Haynes Selling Co., 2013 Sansom St., Philadelphia, Pa.

KRIEBEL, John H. (*A* 1921), 708 Blythe Ave., Drexel Hill, Pa.

KRUEGER, James I. (*M* 1921), Factory Repr. (for mail), 357 Ninth St., and 1920 Sacramento St., San Francisco, Calif.

KUEMPEL, Leon L. (*J* 1929), Sales Engr. (for mail), Minneapolis-Honeywell Regulator Co., and 4917 Garfield Ave., S., Minneapolis, Minn.

KUHLMANN, Rudolf (*M* 1928), 47 Lockwood Ave., New Rochelle, N. Y.

L

LAGODZINSKI, Harry J. (*A* 1927; *J* 1920), 3628 N. Tripp Ave., Chicago, Ill.

LANCE, Joseph F. (*M* 1923), Eighth and Baker Sts., Detroit, Mich.

LANDERS, John J. (*J* 1924), Sales Engr. (for mail), Pacific Steel Boiler Corp., 303 Crosby Bldg., and 823 Smith St., Buffalo, N. Y.

LANE, Alfred M. (*M* 1916), Monarch Metal Products Co., 5020 Penrose St., St. Louis, Mo.

LANG, Lawrence P. (*J* 1925), 549 W. Washington St., Chicago, Ill.

LANGDON, J. D. (*M* 1920), 2030 Fifth Ave., Pittsburgh, Pa.

LANGENBERG, E. B. (*M* 1914), (Council, 1926-1929), Vice-Pres. (for mail), Langenberg Mfg. Co., 4519 N. Euclid Ave., and 6625 Waterman Ave., St. Louis, Mo.

LANGLEY, Frank P. (*A* 1926), 26 Berryman Dr., Snyder, N. Y.

LANNING, E. K. (*A* 1927), Asst. Secy. and Sales Mgr. (for mail), Warren Webster & Co., Camden, and Clayton, N. J.

LaPRAIRIE, Charles (*M* 1926), Crane, Ltd., 1170 Beaver Hall Sq., Montreal, Que., Can.

LARIMER, William McCoy (*M* 1922), Mgr., Htg. Dept. (for mail), Crane O'Fallon Co., 1625 15th St., and 159 W. Second Ave., Denver, Colo.

LARSON, G. L.* (*M* 1923), (Council, 1929), Prof. Steam and Gas Engrg., University of Wisconsin, Madison, Wis.

LARSON, J. M. (*M* 1924), National Regulator Co., 2301 Knox Ave., Chicago, Ill.

LARSON, W. C. (*M* 1925), 4224 N. Winchester Ave., Chicago, Ill.

LATHAM, George (*M* 1924), Engr. and Supt. of Plant (for mail), Edmonton Public School Board, 518 Civic Block, and 11317 91st St., Edmonton, Alberta, Can.

LATHERS, Victor M. (*A* 1929), Rome Brass Radiator Corp., 354 Paul Brown Bldg., St. Louis, Mo.

LATHROP, Dr. Elbert C. (*M* 1926), 645 N. Michigan Ave., Chicago, Ill.

LAU, Anton S. (*M* 1926), Consulting Engr., 51 East 42nd St., New York, N. Y., and (for mail), 35 Woodland Rd., Bloomfield, N. J.

LAUTENSCHLAGER, Fred (*M* 1915), Vice-Pres. and Treas., Kroeschell Boiler Co., 4211 Diversey Ave., and (for mail), 3846 Alta Vista Ter., Chicago, Ill.

LAWSON, William Irvin (*A* 1929), Vice-Pres. and Gen. Mgr., The Buckeye Blower Co., 400 Dublin Ave., and (for mail), 67 W. Dunedin Rd., Columbus, Ohio.

LAWTON, Frank C. (*M* 1928), 145 Buena Vista Ave., Hawthorne, N. J.

LEAHY, Joseph L. (*A* 1928; *J* 1926), 5730 N. Howard St., Philadelphia, Pa.

LeBEAU, John F. (*M* 1924), Pres., John F. LeBeau & Co., Inc., 103 Park Ave., New York, and (for mail), 158-21 84th Dr., Jamaica, N. Y.

LECOMPTE, William G. (*A* 1914), Jenkins Bros., 80 White St., New York, N. Y.

LEEK, Walter (*M* 1903), Managing Director (for mail), Leek & Co., Ltd., 1111 Homer St., and 1114 Pacific St., Vancouver, B. C.

LEES, Herbert K. (*M* 1924; *J* 1912), Secy. (for mail), William Lees, Inc., 548 Washington Blvd., and 4944 Christiana Ave., Chicago, Ill.

LEGEMAN, Ralph E. (*J* 1926), Architect (for mail), Thole & Legeman, 307 American Trust Bldg., and 900 Powell Ave., Evansville, Ind.

LEILICH, Roger L. (*M* 1922), Baltimore Htg. Corp., 425 St. Paul Pl., Baltimore, Md.

LEINROTH, J. Paul (*M* 1929), Gen. Industrial Fuel Repr. (for mail), Public Service Elec. & Gas Co., 80 Park Pl., Newark, and 22 Hillside Ave., Caldwell, N. J.

LEITCH, Arthur S. (*M* 1908), Mgr. (for mail), The Arthur S. Leitch Co., Ltd., 1123 Bay St., and 421 Russell Hill Rd., Toronto, Ont., Can.

LELAND, Warren B. (*M* 1929), Sales Engr., The H. B. Smith Co., Westfield, and (for mail), P. O. Box 1522, Springfield, Mass.

LELAND, William E. (*M* 1915), Partner (for mail), Leland & Haley, 58 Sutter St., San Francisco, and 704 The Alameda, Berkeley, Calif.

LEMMERMAN, Clarence W. (*A* 1927), Eastern Dist. Mgr. (for mail), The Ric-wiL Co., Inc., 101 Park Ave., New York, and 115 Parkside Ave., Brooklyn, N. Y.

LENNON, Joseph O. (*M* 1929), New York Mgr. (for mail), Ilg Elec. Vtg. Co., 15 Park Row, and 180 West 59th St., New York, N. Y.

LENONE, J. M. (*M* 1919), Smith-Totman Co., Room 1207, 122 S. Michigan Ave., and (for mail), 4808 Dorchester Ave., Chicago, Ill.

LEUSCH, Victor William (*A* 1926), 1130 Diamond Ave., South Bend, Ind.

LEWIS, Edward B. (*M* 1924), Engr., Ellerbe & Co., and (for mail), 2283 Commonwealth Ave., St. Paul, Minn.

LEWIS, George C. (*M* 1919), American Htg. & Vtg. Co., 1505 Race St., Philadelphia, Pa.

LEWIS, John G. (*M* 1926), Prop. (for mail), John G. Lewis Plbg. & Htg. Co., 412 East 31st St., and 3522 Campbell St., Kansas City, Mo.

LEWIS, John W. (*M* 1926), 3935 Sansom St., Philadelphia, Pa.

LEWIS, L. L.* (*M* 1918), Secy. (for mail), Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, and 724 Carlton Ave., Plainfield, N. J.

LEWIS, Samuel R.* (*M* 1919), (*Presidential Member*), (Pres., 1914; 2nd Vice-Pres., 1910; Board of Governors, 1909, 1910, 1912; Council, 1914-1915), Consulting Engr., 1155 Old Colony Bldg., 407 S. Dearborn St., Chicago, Ill.

LEWIS, Thornton* (*M* 1919), (*Presidential Member*), (Pres., 1929; 1st Vice-Pres., 1928; 2nd Vice-Pres., 1927; Council, 1923-1930), Pres. (for mail), York Htg. & Vtg. Corp., 1541 Sansom St., Philadelphia, and 327 Leandrillo Rd., Cynwyd, Pa.

LICHTY, A. J. (*J* 1923), Resident Engr., Stone & Webster Engrg. Corp., and (for mail), C. P. Lichty, Martin Bldg., Birmingham, Ala.

LICHTY, C. P. (*M* 1920), Pres. (for mail), C. P. Lichty Engrg. Co., Inc., 1216 Martin Bldg., and 127 Windsor Dr., Birmingham, Ala.

LINDEMAN, Henry (*A* 1927; *J* 1923), 157 Foxall St., Ridgewood, L. I., N. Y.

LINDEMUTH, Nelson Rhoads (*A* 1924), Lindemuth Engrg. Co., Inc., 155 N. George St., York, Pa.

LINER, John J. (*A* 1916), Pres. (for mail), Philadelphia Asbestos Co., 2010 N. Tenth St., Philadelphia, Pa., and Berlin, N. J.

LINHARD, Howard V. (*A* 1921), 7238 Webb Ave., Detroit, Mich.

LINN, Homer R. (*M* 1914), Engr., American Radiator Co., 816 S. Michigan Ave., Chicago, and (for mail), 321 S. Ashland Ave., La Grange, Ill.

LINTON, John P. (*M* 1927), Garth Co., 26 Craig St., W., Montreal, P. Q., Can.

LIPPMAN, Orville S. (*A* 1920), Sales Repr. (for mail), The Kellogg-Mackay Co., 1351 West 37th Pl., and 7251 Princeton Ave., Chicago, Ill.

LITTLE, Edwin R. (*M* 1916), 1918 Ford Bldg., Detroit, Mich.

LIVINGSTON, Bernard B. (*M* 1927), P. O. Box 975, Richmond, Va.

LLOYD, Edward C. (*M* 1927), (for mail), Armstrong Cork & Insulation Co., and 429 W. Walnut St., Lancaster, Pa.

LOCKE, Hiram W. (*M* 1920), 1942 North 20th St., Philadelphia, Pa.

LOCKWOOD, Edwin H. (*M* 1915), Prof. of Mech. Engrg., Yale University, 400 Temple St., and (for mail), 51 Sheldon Ter., New Haven, Conn.

LOEFFLER, Frank X. (*M* 1914), 710 N. Hudson St., Oklahoma City, Okla.

LOH, Nan-Shee (*J* 1927), Salesman, Andersen Meyer & Co., Ltd., and (for mail), 337 Rue Lafeyette, Shanghai, China.

LONG, David Raymond (*M* 1927), Mgr. of Mfg. (for mail), Congoleum-Nairn, Inc., Kearny, and 117 Christopher St., Montclair, N. J.

LONGENECKER, Howard J. (*M* 1917), York Htg. & Vtg. Corp., Bridgeport, Montgomery Co., Pa.

LONGWELL, Henry E. (*M* 1919), 53 Washington Sq., New York, N. Y.

LORD, Frank R. (*M* 1922), Lord, Hawley & Hammel, Inc., 33rd and Thompson Sts., Philadelphia, Pa.

LOVE, Clarence H. (*M* 1919), 317 Chamber of Commerce, Buffalo, N. Y.

LOVEGREN, Harvey M. (*A* 1927), B. Hoffman Mfg. Co., 1819 St. Paul Ave., Milwaukee, Wis.

LOWNSBERY, Benjamin F. (*M* 1920), 21 S. Sycamore St., Wilmington, Del.

LUCE, George D., Jr. (*M* 1919), 3633 N. Harding Ave., Chicago, Ill.

LUCK, Alexander W. (*M* 1919), Pres. and Gen. Mgr. (for mail), Reading Heater & Supply Co., Church and Woodward Sts., Reading, and Reiffton, Pa.

LUCKE, Charles Edward (*M* 1924), Prof. of Mech. Engrg. (for mail), Columbia University, and 845 West End Ave., New York, N. Y.

LUTZ, James H., Jr. (*M* 1928), (for mail), 140 Paxton St., and 1601 Forster St., Harrisburg, Pa.

LUTZ, Paul R. (*J* 1929), Mech. Engr., York Htg. & Vtg. Corp., 16th and Sansom Sts., and (for mail), 2512 S. Lloyd St., Philadelphia, Pa.

LYLE, Ernest T. (*M* 1919), Carrier Engrg. Corp., 39 Cortlandt St., New York, N. Y.

LYLE, J. Irvine (*M* 1911), (*Presidential Member*), (Pres., 1917; Council, 1917-1918), Exec. Vice-Pres. (for mail), Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, and 1200 W. Seventh St., Plainfield, N. J.

LYMAN, Samuel E. (*A* 1924), Elm Court Apts., Apt. A-3, Elm St., Elizabeth, N. J.

LYNCH, Grevirson D. (*Student* 1927), Draftsman, Western Elec. Co., Inc., Kearny, and (for mail), 329 S. Union Ave., Cranford, N. J.

LYNCH, William L. (*M* 1928), Pres. (for mail), Rome-Turney Radiator Co., and 312 N. James St., Rome, N. Y.

M

MacDADE, Ambrose H. (*M* 1923), Sales (for mail), Burnham Boiler Corp., Bourse Bldg., Philadelphia, Pa., and 225 Haddon Ave., Westmont, N. J.

MacDOUGALL, Burgess W. (*M* 1923), 219 Netherwood Ave., Plainfield, N. J.

MacKENZIE, Burt (*M* 1924), Pres. (for mail), B. MacKenzie, Inc., 911 Greensboro Bk. & Trust Bldg., and 111 Westover Ter., Greensboro, N. C.

MacKENZIE, John J. (*M* 1925), Htg. Engr., McNaughton & MacKenzie, 1029 Shaw St., and (for mail), 664 Shaw St., Toronto, Ont., Can.

MACKIE, James (*M* 1917), Owner (for mail), 357 Langside St., and 254 Montrose St., Winnipeg, Manitoba, Can.

MADISON, Richard D. (*M* 1926), Buffalo Forge Co., 490 Broadway, Buffalo, N. Y.

MAGINN, Peter F. (*M* 1908), 207 Fulton Bldg., Pittsburgh, Pa.

MaGIRL, Willis James (*J* 1927), MaGirl Foundry & Furnace Works, 401-413 E. Oakland Ave., Bloomington, Ill.

MAHONEY, David John (*A* 1926), Br. Mgr. (for mail), Johnson Service Co., 503 Franklin St., and 703 W. Ferry St., Buffalo, N. Y.

MAIER, George M. (*M* 1921), (for mail), Executive Dept., American Radiator Co., 40 West 40th St., and Peldean Court, Pelham, N. Y.

MAIER, Herman F. (*M* 1926), 7124 Morgan St., Chicago, Ill.

MALLIS, William (*M* 1914), 326 Lyon Bldg., Seattle, Wash.

MALONE, Dayle G. (*M* 1929; *A* 1925), Vice-Pres., Hardin-Lavin Co., 121-31 W. Pershing Rd., and (for mail), 7015 Merrill Ave., Windsor Park Sta., Chicago, Ill.

MANAHAN, James E. (*J* 1926), Sales Engr., St. Louis County Gas Co., 231 W. Lockwood Ave., and (for mail), 6732 Oakland Ave., Webster Groves, Mo.

MANDEL, Henry J. (*A* 1929), Gen. Mgr., The Columbia Burner Co., 1649-51 Dorr St., and (for mail), 521 W. Bancroft St., Toledo, O.

MANDEVILLE, Edgar W. (*M* 1914), 1171 East 37th St., Brooklyn, N. Y.

MARSCHALL, Peter J. (*J* 1927), E. V. Hill Co., 121 N. Clark St., Chicago, Ill.

MARSHALL, H. Hall (*M* 1923), Consulting Engr. (for mail), 37 West 43rd St., New York, and 63 Pine St., Garden City, N. Y.

MARTENIS, John V. (*M* 1918), Associate Prof., Mchy. Design (for mail), University of Minnesota, and 114 Melbourne Ave., S. E., Minneapolis, Minn.

MARTIN, Albert B. (*M* 1917), Mgr. (for mail), Kewanee Boiler Corp., 1858 S. Western Ave., Chicago, and 997 Vine St., Winnetka, Ill.

MARTIN, George W. (*M* 1911), 141 East 29th St., New York, N. Y.

MARTIN, Jeremiah F. (*M* 1926), Pres., J. F. Martin Co., Inc., 139 Taft St., and (for mail), 166 Glenwood Ave., Pawtucket, R. I.

MARTIN, O. Waldemar (*M* 1925), Br. Mgr. (for mail), Flaxlinum Insulating Co., 228 N. La Salle St., Chicago, and 1024 Hinman Ave., Evanston, Ill.

MASON, James J. (*M* 1918), Sales Promotion (for mail), National Radiator Corp., 935 East 63rd St., Cleveland, and 936 Whitby Rd., Cleveland Heights, Ohio.

MASON, Ray B. (*M* 1925), Kewanee Boiler Co., 2014 Wyandotte St., Kansas City, Mo.

MATCHETT, James C. (*M* 1923), Vice-Pres. and Gen. Mgr. (for mail), Illinois Engrg. Co., Racine Ave. at 21st St., and 9936 S. Winchester Ave., Chicago, Ill.

MATHEY, Nicholas J. (*M* 1915), Mathey Plbg. Co., 31 Third Ave., Le Mars. Iowa.

MATHIS, Eugene (*M* 1922), New York Blower Co., 32nd and Shields Ave., Armour P. O. Sta., Chicago, Ill.

MATHIS, Henry (*M* 1921), 10317 Oakley Ave., Chicago, Ill.

MATHIS, Julien W. (*A* 1921), New York Blower Co., 2248 S. Halsted St., Chicago, Ill.

MATHY, Joseph, Jr. (*M* 1925), 3415 West 61st Pl., Chicago, Ill.

MATSON, Taylor (*A* 1925), 6141 Girard Ave., Philadelphia, Pa.

MATTHEWS, Charles R. (*M* 1924), Htg. Engr. (for mail), Warren Webster & Co., 76 Summer St., Boston, and 48 Dana St., Cambridge, Mass.

MATTHIESSEN, H. G. F. (*M* 1923), Sales Engr., Hoffman Specialty Co., 25 West 45th St., New York, N. Y., and (for mail), 394 Centre St., Nutley, N. J.

MATZEN, Harry B. (*M* 1919), Dist. Sales Mgr. (for mail), Carrier Engrg. Corp., 1824 Union Trust Bldg., Cleveland, and 3115 Chadbourne Rd., Shaker Heights, Ohio.

MAUER, William J. (*M* 1919), Vice-Pres. and Sales Mgr. (for mail), Dwyer Equipment Co., 4534 W. North Ave., Chicago, and 2525 Colfax St., Evanston, Ill.

MAURER, Edward D. (*M* 1921), 1527 Mars Ave., Lakewood, Ohio.

MAUTSCH, Robert Henri (*A* 1928), Mgr-Dir., Engr., Compagnie Belge des Freins Westinghouse, Ave. Louise 97, Brussels, Belgium.

MAY, A. O. (*J* 1928), Sales Engr. (for mail), Stannard Power Equipment Co., 53 W. Jackson Blvd., Chicago, and 4824 Lee St., Niles Center, Ill.

MAY, Edwin A. (*M* 1906), 171 N. Kenilworth Ave., Oak Park, Ill.

MAYER, Robert S. (*M* 1911), Htg. and Vtg. Engr., R. F. D. No. 1, Erie, Pa.

MAYETTE, Charles E. (*M* 1926), Service Equipment Engr. (for mail), United Engrs. & Constructors, Inc., 112 N. Broad St., Philadelphia, and S. 203 Stratford Court, Lansdowne, Pa.

McCAFFREY, H. Grattan (*M* 1922), Sheldons, Ltd., W. Main St., Galt, Ont., Can.

McCANN, Frank G. (*M* 1903), (Council, 1914-1915), Chief of Htg. and Vtg. Div. (for mail), Board of Education, 131 Livingston St., and 1616 E. Tenth St., Brooklyn, N. Y.

McCARTHY, Bernard J. (*M* 1925), Sales Engr. (for mail), The Trane Co., 844 Rush St., and 420 Diversey Pkwy., Chicago, Ill.

McCARTHY, Charles J. (*M* 1919), (for mail), 807 Otis Bldg., and 533 South 55th St., Philadelphia, Pa.

McCAULEY, James H. (*M* 1921), 224 N. Pine St., Chicago, Ill.

McCLELLAN, James E. (*M* 1922), Asst. Mgr. (for mail), American Blower Corp., 228 N. La Salle St., and 4443 Greenview St., Chicago, Ill.

McCLENATHAN, Robert (*M* 1927), Board of Education, Central High School, Akron, Ohio.

McCLINTOCK, A., Jr. (*M* 1928; *J* 1920), Htg. Engr. (for mail), A. McClintock & Sons, 1937 Ridge Ave., Philadelphia, and 121 Rochelle Ave., Wissahickon, Philadelphia, Pa.

McCLINTOCK, A., Sr. (*M* 1917), Pres., A. McClintock & Sons, 1937 Ridge Ave., Philadelphia, Pa.

McCLINTOCK, John L. (*M* 1917), Htg. Engr. (for mail), A. McClintock & Sons, 1937 Ridge Ave., Philadelphia, and 933 E. Rittenhouse St., Germantown, Philadelphia, Pa.

McCOLL, Jay R.* (*M* 1916), (*Presidential Member*), (Pres., 1922; 1st Vice-Pres., 1921; 2nd Vice-Pres., 1920; Council, 1920-1923), 2348 Penobscot Bldg., Detroit, Mich.

McCONACHIE, L. L. (*A* 1928), McConachie & Reid, 8817 Mack Ave., and (for mail), 1415 Harvard Rd., Detroit, Mich.

McCONNER, Charles R. (*A* 1922), Dist. Mgr. (for mail), York Htg. & Vtg. Corp., 4-266 General Motors Bldg., and 3290 Rochester St., Detroit, Mich.

McCORMACK, Edward T. (*A* 1923), Dist. Mgr. (for mail), Pierce, Butler & Pierce Mfg. Corp., 41 East 42nd St., New York, N. Y., and Stanton, N. J.

McCOY, Thomas F. (*M* 1924), Mgr. (for mail), The Powers Regulator Co., 125 St. Botolph St., Boston, and Glen Rd., Wellesley Farms, Mass.

McCREA, Lester W. (*M* 1920), West 27th and Sisson Sts., Baltimore, Md.

McCREARY, Julian Ledrew (*A* 1928), Room 11, Prince Theater Bldg., Ambridge, and Dettmar Ave., Baden, Pa.

McCREERY, Hugh Joseph (*M* 1922), Mech. Engr., 530 Standard Bk. Bldg., Vancouver, B. C.

McCUNE, Byron V. (*M* 1928), Sales Engr. (for mail), 101 W. Yakima Ave., and 211 North 24th St., Yakima, Wash.

McDONALD, John J. (*M* 1927), Mgr., Albert Pick-Barth Co., John Van Range Co., 85 Kneeland St., Boston, and (for mail), 26 Chestnut St., Malden, Mass.

McDONNELL, Everett N. (*M* 1923), Owner (for mail), McDonnell & Miller, Wrigley Bldg., 400 N. Michigan Ave., and 627 Arlington Pl., Chicago, Ill.

McELLROY, G. S. (*M* 1925), R. D. 2, Glenshaw, Pa.

McEVOY, William J. (*M* 1917), Kitzelman Co., 3615 S. Morgan St., Chicago, Ill.

McFARLAND, William P. (*A* 1923), 6650 N. Maplewood Ave., Chicago, Ill.

McGEORGE, R. H. (*M* 1927), Mgr. (for mail), Ilg Elec. Vtg. Co., 415 Brainard St., and 14565 Brace St., Detroit, Mich.

McGINNESS, J. E. (*M* 1903), Pres., McGinness, Smith & McGinness Co., 527 First Ave., Pittsburgh, Pa.

McGLENN, G. Raymond (*M* 1915), 259 Lormore St., Elmira, N. Y.

McGRAIL, Thomas Ernest (*M* 1926), 316 Belmore Ave., Montreal, Que., Can.

McGREGOR, George H. (*M* 1920), Mgr. (for mail), Western Htg. Co., 2250 N. Cicero Ave., and 500 Leonard St., Park Ridge, Ill.

McGUIGAN, L. A. (*A* 1919), 724 Hastings St., Pittsburgh, Pa.

McHENRY, Robert W. (*M* 1921), Sales Engr., Empire Brass Mfg. Co., Ltd., 110 Adelaide St., W., and (for mail), 236 Eglinton Ave. E., Toronto, Ont., Can.

McILVAINE, John H.* (*M* 1929), Pres. and Treas. (for mail), McIlvaine Burner Corp., 749 Custer Ave., Evanston, and Lake Forest, Ill.

McINTIRE, James F. (*M* 1915; *A* 1914), (Council, 1926-1928), Vice-Pres. (for mail), U. S. Radiator Corp., P. O. Box 686, 1056 First National Bk. Bldg., and 3261 Sherbourne Rd., Detroit, Mich.

McINTOSH, Fabian C. (*M* 1921; *J* 1917), (Council, 1919), Mgr. (for mail), Johnson Service Co., 10 E. North Diamond St., and 3334 Portola St., Pittsburgh, Pa.

McKENNA, William N. (*Life Member; M* 1912), Treas. (for mail), William N. McKenna Co., 79 Chestnut St., and 21 W. Cedar St., Boston, Mass.

McKIEVER, William H. (*M* 1897; *J* 1896), Pres. (for mail), William H. McKiever, Inc., 247 West 13th St., New York, and 479 Eighth St., Brooklyn, N. Y.

McLAIN, Roland D. (*M* 1921), 716 Vernon Ave., Williamsport, Pa.

McLAUGHLIN, Joseph D. (*J* 1928), Mgr. (for mail), Braley & McLaughlin, 166 Aborn St., and 45 Roslyn Ave., Providence, R. I.

McLAUGHLIN, Joseph J. (*A* 1928), 1831 South 23rd St., Philadelphia, Pa.

McLEAN, Dermid (*M* 1917), Consulting Engr. (for mail), McColl, Snyder & McLean, 2304 Penobscot Bldg., and 12651 Birwood Ave., Detroit, Mich.

McLEAN, Ivory D. (*M* 1924), Pres., McLean & Cousens Co., 65 Chandler St., Boston, Mass.

McLEISH, William Scott (*J* 1928), Mech. Engr. (for mail), The Ric-wiL Co., Union Trust Bldg., Cleveland, and 1646 Wagar Ave., Lakewood, O.

McLELLAND, H. Burton (*A* 1912), Jenkins Bros., 646 W. Washington Blvd., Chicago, Ill.

McMAHON, Thomas W. (*M* 1928), American Blower Corp., 819 Cotninental Bk. Bldg., Indianapolis, Ind.

McMICHAEL, Peter (*A* 1925), Apt. 7, 41 Spadina Rd., Toronto, Ont., Can.

McMORRAN, Francis J. (*M* 1917), 230 E. Argonne Dr., Kirkwood, Mo.

McMURRAY, John (*M* 1920), Iron City Htg. Co., 843 Jackson St. N., South Pittsburgh, Pa.

McMURRER, Louis J. (*M* 1928; *J* 1924), Pres., The McMurrer Co., 303 Congress St., Boston, Mass.

McNAIR, E. E. (*M* 1915), (2nd Vice-Pres., 1923; Council, 1921-1923), Vice-Pres., U. S. Radiator Corp., and Pres. Pacific Steel Boiler Corp., 1056 First National Bk. Bldg., Detroit, Mich.

McVEHIL, Earl W. (*M* 1923), McVehil Plbg. Co., 40 E. Wheeling St., Washington, Pa.

MEAD, Edward A. (*M* 1926), Sales Dept. (for mail), Nash Engrg. Co., South Norwalk, and 5 Thames St., Norwalk, Conn.

MEAD, W. R. (*M* 1924), Mgr., Htg. & Piping Contractors Association of Alameda County, 354 Hobart St., Oakland, and (for mail), 1685 Euclid Ave., Berkeley, Calif.

MEADOWS, Frank H. (*M* 1923), 94 Second St., Milwaukee, Wis.

MEARA, John J. (*J* 1925), Engr. (for mail), Hunt Htg. Co., 1515 Olive St., and 5046 Wabada Ave., St. Louis, Mo.

MEHAFFEY, William Chambers (*M* 1922), Engr., Chambersburg Construction Co., Chambersburg, Pa.

MEHNE, Carl A. (*M* 1929), Livingston St., Valhalla, N. Y.

MEHRING, George (*Charter Member*), Pres., Mehring & Hanson Co., 162-166 N. Clinton St., Chicago, Ill.

MEIER, Konrad* (*M* 1916), Rychenbergstrasse 57, Winterthur, Switzerland.

MELLON, James T. J. (*M* 1911), (for mail), Mellon Co., 4415-21 Ludlow St., and 431 North 63rd St., Philadelphia, Pa.

MENK, R. W. (*M* 1919), 814 Clement St., Joliet, Ill.

MENSING, Frederick D. (*M* 1920), Consulting Engr. (for mail), Mensing & Co., 928 Presser Bldg., 1713 Sansom St., and 2845 Frankford Ave., Philadelphia, Pa.

MENZIES, Frederick Robert (*J* 1926), The Trane Co., 410 Temple St., New Haven, Conn.

MERKEL, Fred P. (*M* 1924), 302 14th Ave., Belmar, N. J.

MERRELL, Spencer A. (*A* 1927), Pres. (for mail), Merrell & Co., Inc., 2220 Olive St., and 4397 McPherson St., St. Louis, Mo.

MERRILL, Carle J. (*M* 1919), Treas., C. J. Merrill, Inc., 54 St. John St., Portland, Maine.

MERRITT, Cecil James (*M* 1925), Asst. Gen. Mgr., C. J. Doughty & Co., 30 Brenan Rd., Shanghai, China.

MERTZ, Walter A. (*M* 1919), Secy. (for mail), Kehm Bros. Co., 51 E. Grand Ave., and 3753 N. Keeler Ave., Chicago, Ill.

MERVINE, Thomas R. (*M* 1922), Member of Firm, Mervine Bros., 616 N. Fifth St., and (for mail), 1009 Pennsylvania Ave., Brookline, Upper Darby P. O., Delaware County, Pa.

MERWIN, Gile E. (*M* 1924; *J* 1923), Htg. Engr., Rockford Brass Works, and (for mail), 1509 Grant Ave., Rockford, Ill.

MESSMER, George Ellis (*M* 1929; *A* 1929; *J* 1925), Sales Mgr. (for mail), Bridge & Beach Mfg. Co., 4204 N. Union Blvd., and 2914 N. Euclid Ave., St. Louis, Mo.

METCALF, Ralph H. (*J* 1929), C. A. Dunham Co., 3605 Laclede Bldg., St. Louis, Mo.

MEWSHAW, James P. (*M* 1923), Sales Engr. (for mail), 915-16 Barr Bldg., and 2700 35th Pl. N. W., Washington, D. C.

MEYER, Frank L. (*J* 1928), Asst. Engr., Meyer Furnace Co., and (for mail), 220 Moss Ave., Peoria, Ill.

MEYER, Henry C., Jr. (*M* 1898), (Council, 1915-1916), 101 Park Ave., New York, N. Y.

MEYER, John W. (*M* 1921), Mgr., Order and Credit Depts. (for mail), American Blower Corp., 6000 Russell St., and 700 Seward Ave., Detroit, Mich.

MEYER, John W. (*A* 1929), (for mail), The Philadelphia Elec. Co., 1000 Chestnut St., and 223 South 51st St., Philadelphia, Pa.

MICKIEWICZ, Stanley J. (*J* 1928), Htg. and Vtg. Engr. (for mail), Typhoon Fan Co., 345 West 39th St., and 532 East 147th St., New York, N. Y.

MIKESH, John James (*J* 1928), Wayzata Plbg. & Htg. Co., Wayzata, Minn.

MILES, James C.* (*M* 1914), Vice-Pres. and Chief Engr., The Warm Air Furnace & Fan Co., 6511 Cedar Ave., and 1863 Crawford Rd., Cleveland, Ohio.

MILLAR, Rowland J. (*M* 1925), Vice-Pres. and Gen. Mgr. (for mail), Pease Foundry Co., Ltd., 118 King St. E., and 53 Oakmount Rd., Toronto, Ont., Can.

MILLER, Alan A. (*A* 1926), Mgr., Htg. Dept., Tomlinson Co., Inc., 3650 N. Tenth St., Philadelphia, and (for mail), 731 Cornell Ave., Drexel Hill, Pa.

MILLER, Charles A. (*A* 1917), H. B. Smith Co., 10 East 39th St., New York, N. Y.

MILLER, Charles W. (*M* 1919; *J* 1908), Pres. (for mail), The Rado Co., 192 Reed St., Milwaukee, and R 1, Box 62, Menomonee Falls, Wis.

MILLER, Floyd A. (*M* 1911), 477 Federal Bldg., Chicago, Ill.

MILLER, Harry M. (*M* 1920), 6089-91 Plankington Bldg., Milwaukee, Wis.

MILLER, Harvey N. (*M* 1921), Estimating Engr., O. J. Dykman, 606 Building and Loan Bldg., and (for mail), 1850 Gidding Ave. S. E., Grand Rapids, Mich.

MILLER, Henry F. (*A* 1928), Dist. Mgr. (for mail), Keasbey & Mattison Co., Schaff Bldg., 15th and Race Sts., Philadelphia, and 11 S. Swarthmore Ave., Ridley Park, Pa.

MILLER, James E. (*M* 1914; *J* 1912), C. W. Johnson, Inc., 211 N. Desplaines St., Chicago, Ill.

MILLER, John F. G. (*M* 1916), American Blower Co., 6004 Russell St., Detroit, Mich.

MILLER, L. B. (*M* 1926), Asst. Sales Mgr. (for mail), Time-O-Stat Controls Co., and 1843 E. Beardsley Ave., Elkhart, Ind.

MILLER, Merl William (*J* 1926), Trane Co., La Crosse, Wis.

MILLER, Peter (*M* 1926), Engr., Davidson & Miller, Inc., 119 Broadway, Saranac Lake, N. Y.

MILLER, Robert B. (*M* 1922), Pres., Miller & Brady, Inc., 210 East 38th St., New York, N. Y.

MILLER, Robert T. (*A* 1927), Masonite Corp., 504 Conway Bldg., Chicago, Ill.

MILLER, Tolbert G. (*A* 1929; *J* 1921), 11 N. Second St., Wormleysburg, Pa.

MILLER, William C. (*M* 1918), Htg. Specialties, Co., 110 Walnut St., Philadelphia, Pa.

MILLIKEN, J. H.* (*M* 1923), Vice-Pres. and Br. Mgr. (for mail), Reed Air Filter Co., 228 N. La Salle St., Chicago, and 1021 Ridge Court, Evanston, Ill.

MILLIS, Linn W. (*M* 1918), Secy., Security Store & Mfg. Co., 1630 Oakland St., and (for mail), 3534 Wabash Ave., Kansas City, Mo.

MILWARD, Robert King (*A* 1920), Mgr. (for mail), U. S. Radiator Corp., 517 Dime Bk. Bldg., and 2675 Tuxedo Ave., Detroit, Mich.

MINNICH, Harry S. (*M* 1921), 4526 Walnut St., Philadelphia, Pa.

MITCHELL, Charles H. (*M* 1924), 179 Thatcher St., Mattapan P. O., Milton, Mass.

MODIANO, Rene (*M* 1925), Continental Sales Engr., Carrier Engrg. Co., Ltd., 4 Rue d'Aguesseau, Paris 8eme, and (for mail), 55 Blvd. Beauséjour, Paris 16eme, France.

MOFFETT, William S. (*M* 1907), Staunton, Va.

MOLER, William H. (*M* 1927; *J* 1923), Sales Engr., Carrier Engrg. Corp., 2706 Commerce St., and (for mail), 2110 Bennett Ave., Dallas, Tex.

MOLTZ, George N. (*A* 1925), 320 Granfiean Blvd., Williamsport, Pa.

MONAGHAN, T. H. (*M* 1914), Pres., Robert Gordon, Inc., 22 W. Austin Ave., Chicago, Ill.

MONDAY, Charles E. (*M* 1920), (for mail), Chas. E. Monday & Co., 1323 Fairmount Ave., Philadelphia, Pa., and 15 N. Chelsea Ave., Atlantic City, N. J.

MONROE, Harry E. (*A* 1928), 1907 East 78th St., Chicago, Ill.

MONROE, L. O. (*A* 1925; *J* 1917), Gen. Mgr., Nichols Products Corp., 12953 Greeley Ave., Detroit, Mich.

MONTGOMERY, W. Ray (*A* 1923), Montgomery Bros., 500 N. Dearborn St., Chicago, Ill.

MOON, L. Walter (*M* 1915), Engr. (for mail), Bradley Htg. Co., 3834 Olive St., and 6069 Gates Ave., St. Louis, Mo.

MOORE, H. Lee (*M* 1919), (Council, 1927-1928), Buffalo Forge Co., 927 Union Trust Bldg., Pittsburgh, Pa.

MOORE, H. S. (*A* 1923), Sales Mgr. (for mail), Atlas Engrg. & Mch. Co., Ltd., 23 River St., Toronto, Ont., Can.

MOORE, Raymond F. (*A* 1926), Architect (for mail), 415-18 O. R. C. Bldg., and 1714 Park Ave., Cedar Rapids, Iowa.

MOORE, Robert Edwin (*A* 1928), Mgr., B. & G. Heater Div., Bell & Gossett Co., 3000 Wallace St., and (for mail), 2102 Home Ave., Chicago, Ill.

MORAN, Frank E. (*M* 1922), Pres. (for mail), Ben Rigby, Inc., 6850 Grand Ave., Chicago, and 3034 S. Maple Ave., Berwyn, Ill.

MORAN, Roger J. (*M* 1926), 51 Allen, Buffalo, N. Y.

MORGAN, C. Stanley (*A* 1919), Owner (for mail), 445 W. Larned St., Detroit, and 1036 Devonshire Rd., Grosse Pointe Park, Mich.

MORGAN, Francis H. (*M* 1912), J. F. Morgan & Son, Inc., 67 Blake St., Lynn, Mass.

MORGAN, Glenn C. (*M* 1911), Partner, Morgan-Gerrish Co., Affay Bldg., 800 La Salle Ave., Minneapolis, Minn.

MORGAN, J. Scott (*A* 1922), 7277 Tioga St., Pittsburgh, Pa.

MORGAN, Robert C. (*M* 1915), 1200 Locust St., Philadelphia, Pa.

MORRILL, Raleigh Dudley (*M* 1928), Prof., Experimental Engrg., New York University, University Heights, New York, N. Y.

MORRIS, C. Raymond (*M* 1921), 55 Lexington Ave., Passaic, N. J.

MORRIS, F. H. (*M* 1912), (for mail), Grinnell Co., Inc., 5203 Hamilton Ave., and 1233 East 125th St., Cleveland, Ohio.

MORROW, Charles F. (*A* 1919), National Radiator Co., 1509 Arrott Bldg., Wood and Fourth Aves., Pittsburgh, Pa.

MORSE, C. T. (*M* 1921), Vice-Pres. and Sales Mgr. (for mail), American Blower Corp., 6000 Russell St., 16225 Shaftsbury Ave., Detroit, Mich.

MOSHER, Clarence H. (*A* 1919), Dist. Sales Repr., Consolidated Ashcroft Hancock Co., Inc., Elias St., Bridgeport, Conn., and (for mail), 624 Genesee Bldg., Buffalo, N. Y.

MOSHER, Roy Bradford (*A* 1927), Mgr. (for mail), Modine Mfg. Co., 424 Baker Bldg., and 3236 Irving Ave. S., Minneapolis, Minn.

MOSS, Edward (*M* 1920), 1130 Atlantic Ave., Brooklyn, N. Y.

MOTEJL, J. A. (*M* 1917), 220 16th Ave., Cedar Rapids, Iowa.

MOTT, Abram C., Jr. (*M* 1921), Pres. (for mail), Abram Cox Co., American and Dauphin Sts., Philadelphia, and Lansdale, Pa.

MOULDER, Albert W.* (*M* 1917), Mgr., Htg. Power and Industrial Piping Div. (for mail), Grinnell Co., Inc., and 62 Humboldt Ave., Providence, R. I.

MOULTON, David (*M* 1926), Mech. Engr. (for mail), Monks & Johnson, 99 Chauncy St., Boston, and 35 Glen St., Melrose, Mass.

MOWER, William P. (*M* 1924), Warren Webster Co., 76 Summer St., Boston, Mass.

MUELLER, Paul E. (*M* 1919), Pres. (for mail), The Paul E. Mueller Co., 320 Park St., and 343 Summit Ave., Milwaukee, Wis.

MUIR, George A. (*M* 1917), Consulting Engr., 168 N. Michigan Ave., Chicago, and (for mail), 234 S. Scoville Ave., Oak Park, Ill.

MUNDER, John F., Jr. (*M* 1927; *J* 1924), Mgr., Trade Div. (for mail), American Blower Corp., 50 Church St., New York, N. Y., and 193 River Edge Rd., Tenafly, N. J.

MUNIER, Leon L. (*M* 1919; *J* 1915), Secy-Treas. (for mail), Wolff & Munier, Inc., 222 East 41st St., New York, and 610 Lafayette Ave., Mt. Vernon, N. Y.

MUNRO, Edward A. (*Charter Member*), Richardson & Boynton Co., 260 Fifth Ave., New York, N. Y.

MUNSON, Morris G. (*M* 1925), Herman Nelson Corp., Moline, Ill.

MURPHY, Edward T.* (*M* 1915), 39 Cortlandt St., New York, N. Y.

MURPHY, Howard C.* (*M* 1923), Vice-Pres. (for mail), Reed Air Filter Co., 215 Central Ave., Louisville, and Lightfoot Rd., Green Hills, Louisville, Ky.

MURPHY, Joseph R. (*A* 1925), Sales Mgr., Taco Heaters, Inc., 342 Madison Ave., New York, N. Y., and Riverside Ter., Riverside, Conn.

MURPHY, William A. (*M* 1926), Mgr. (for mail), McDonnell & Miller, 5936 Grand Central Terminal Bldg., New York, and 172 Myrtle Ave., Larchmont, N. Y.

MURPHY, William R. (*M* 1911), Room 602, 1505 Race St., Philadelphia, Pa.

MURRAY, Thomas F. (*M* 1923), Engr., State Architect, and (for mail), 300 Washington Ave., Albany, N. Y.

MUSAUS, John, Jr. (*M* 1923), 5912 New Utrecht Ave., Brooklyn, N. Y.

MUTH, Herbert (*M* 1912), Pres. and Treas. (for mail), Muth Htg. Co., 4338 N. Western Ave., and 4117 Greenview Ave., Chicago, Ill.

MYERS, George W. F. (*A* 1928; *J* 1923), Dist. Mgr., York Htg. & Vtg. Corp., 1514 Chemical Bldg., St. Louis, and (for mail), 476 Pasadena Ave., Webster Groves, Mo.

MYERS, Joseph E. (*A* 1929), Sales Engr., Marine Galligan Co., 14 South 20th St.. Philadelphia, and (for mail), 98 W. Marshall Rd., Lansdowne, Pa.

MYRICK, James W. H. (*M* 1909), New England Air Conditioning Co., 53 Devonshire St., Boston, Mass.

N

NACEY, Harry M. (*M* 1908), Pres. and Gen. Mgr. (for mail), P. Nacey Co., 927 S. State St., and 229 Lake Shore Dr., Chicago, Ill.

NADEN, Lester James (*J* 1925), 131 Southern Blvd., Albany, N. Y.

NAROWETZ, Louis L., Jr. (*M* 1929; *A* 1912), Secy. and Active Head (for mail), Narowetz Htg. & Vtg. Co., 1711-1717 Maypole Ave., Chicago, and 112 Park Ave., Park Ridge, Ill.

NASON, George Lewis (*M* 1929; *A* 1929; *J* 1927), 31 N. Franklin St., Holbrook, Mass.

NASS, A. F. (*M* 1927), Secy-Treas. (for mail), McGinness-Smith & McGinness Co., 527 First Ave., Pittsburgh, and Elmhurst and Hillcrest Rd., Greentree Boro, R. D. 8, Crafton P. O., Pa.

NATKIN, Benjamin* (*M* 1909; *J* 1907), Pres. (for mail), Natkin Engrg. Co., 314 W. Tenth St., and 5211 Rockhill Rd., Kansas City, Mo.

NAYLOR, Ben C. (*A* 1922), Sales Mgr., Standard Asbestos Mfg. & Insulation Co., 210 Scott Ave., and 3232 Windsor Ave., Kansas City, Mo.

NEAL, Harry W. (*M* 1928), 1324 N. Cap Ave., Indianapolis, Ind.

NEALE, Laurance I. (*A* 1927), Gen. Sales Mgr. (for mail), Atlantic Gypsum Products Co., 40 Rector St., and 49 West 57th St., New York, N. Y.

NEIDECK, Albert A. (*J* 1927), Engr., Peter Sinnott Htg. Co., 621 Tiffany St., and (for mail), 2134 Wallace Ave., Bronx, N. Y.

NEILER, Samuel G. (*M* 1898), Neiler & Rich Co., 431 S. Dearborn St., Chicago, Ill.

NEITZEL, Carl W. (*M* 1921), 10724 Hathway Ave., Cleveland, Ohio.

NELSON, D. W.* (*M* 1928), Asst. Prof. in Steam & Gas Engrg. (for mail), Engineering Bldg., University of Wisconsin, and 3214 Oakridge Ave., Madison, Wis.

NELSON, Frank, Jr. (*M* 1923), Prop. (for mail), Nelson Piping & Equipment Co., 706 Delancey St., Philadelphia, and 6349 Greenway Ave., West Philadelphia, Pa.

NELSON, George Augustus (*M* 1928), Sales Mgr. (for mail), Skinner Bros. Mfg. Co., 949 Broadway, and 2336 University Ave., New York, N. Y.

NELSON, George O. (*M* 1923), Carstens Bros., Ackley, Iowa.

NELSON, Harold A. (*M* 1926), 236 S. La Pere St., Beverly Hills, Calif.

NELSON, Herman W. (*M* 1909), 1824 Third Ave., Moline, Ill.

NELSON, Ralph L. (*M* 1917; *J* 1913), N. 3823 Normandie St., Sopkane, Wash.

NELSON, Richard H. (*J* 1928), Production Mgr., Herman Nelson Corp., Moline, and (for mail), Longview Apts., Rock Island, Ill.

NELSON, Roy O. (*J* 1928), Htg. and Vtg. Engr. (for mail), The Ensign Engrg. Co., 35 E. Wacker Dr., Room 3536, and 2321 Waveland Ave., Chicago, Ill.

NESBITT, Albert J.* (*M* 1921; *J* 1921), State Road and Rhawn St., Holmesburg Junction, Pa.

NESBITT, John J. (*M* 1923), State Road and Rhawn St., Holmesburg Junction, Pa.

NESDAHL, Eilert (*M* 1915), Sales Engr., Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, and (for mail), 1453 Concord Pl., Elizabeth, N. J.

NESMITH, O. Earl (*A* 1928), 107 Warner Ave., Bloomington, Ill.

NEWCOMB, Raymond (*M* 1927; *A* 1927; *J* 1924), 570 Seventh Ave., New York, and (for mail), 25 Putnam Ave., White Plains, N. Y.

NEWPORT, Charles F.* (*M* 1906), Engr., Weil-McLain Co., Michigan City, Ind., and (for mail), 10001 Longwood Dr., Chicago, Ill.

NICELY, John Eyster (*A* 1925), Vice-Pres. and Sales Mgr., Corbit Bros. Plbg. & Htg. Corp., Inc., 149 N. Fifth St., and (for mail), 1208 Marion St., Reading, Pa.

NICHOLLS, Percy* (*M* 1920), Supervising Engr., Fuel Section (for mail), U. S. Bureau of Mines, and 273 N. Craig St., Pittsburgh, Pa.

NICHOLS, George B. (*M* 1915), (Council, 1919-1920), Mech. Engr., Gibbs & Hill, Cons. Engrs., Pennsylvania Station, New York, N. Y.

NICOL, Norman C. (*M* 1923), C. H. Sta., Box 542, New York, N. Y.

NIESTRATH, Walter H. (*A* 1921), Sales Repr., Jas. P. Marsh & Co., 2073 Southport Ave., Chicago, Ill., and (for mail), 3324 S. Jefferson Ave., St. Louis, Mo.

NILSON, Andrew (*M* 1917), 5407 Wayne Ave., Chicago, Ill.

NILSON, Karl A. (*J* 1926), Secy. (for mail), Nilson Bros., 3222 N. Halsted St., and 5633 N. Mozart St., Chicago, Ill.

NOBBS, Walter W. (*M* 1919), 50 Fairhazel Gardens, London, N. W. 6, England.

NOBIS, Harry M. (*M* 1914), 1827 Stanwood Rd., East Cleveland, Ohio.

NOBLE, Milner (*A* 1929; *J* 1924), Aerofin Corp., 750 Frelinghuysen Ave., Newark, N. J.

NOLAN, James Joseph, Jr. (*J* 1929), (for mail), Carrier Engr. Corp., 850 Frelinghuysen Ave., Newark, N. J., and Lebanon Springs, N. Y.

NOLAND, Lloyd U. (*M* 1915), 408 Cal-Wayne Bldg., Ft. Wayne, Ind.

NOLAND, Ralph Waldo (*M* 1914), Consulting Engr. (for mail), 408 Cal-Wayne Bldg., and 910 Kensington Blvd., Ft. Wayne, Ind.

NOLL, William F. (*M* 1924), 1188 45th St., Milwaukee, Wis.

NORDINE, Louis F. (*M* 1914), Vice-Pres., The Herman Nelson Corp., and (for mail), 1170 25th St., Moline, Ill.

NORMAN, Mehrold A. (*M* 1926), 549 W. Washington St., Room 506, Chicago, Ill.

NOTTBERG, Henry J. (*M* 1919), Secy-Treas. (for mail), U. S. Engrg. Co., 914-16 Campbell St., and 213 S. Bales, Kansas City, Mo.

NOVOTNEY, Thomas A. (*M* 1928), Mgr. (for mail), Research and Planning Dept., National Radiator Corp., and 180 Ohio St., Johnstown, Pa.

NOYES, George T. (*M* 1928), Treas. and Engr., The Allen Plbg. Co., 283 Main St., and (for mail), 27 Church St., Presque Isle, Maine.

NULSEN, Carl A. (*M* 1919), Mgr., Htg. & Power Dept. (for mail), Hanley & Co., 6 N. Clark St., and 931 Ainslie St., Chicago, Ill.

NUSBAUM, Lee* (*M* 1915), (for mail), Pennsylvania Engrg. Co., 1119-21 N. Howard St., Philadelphia, and 315 Carpenter Lane, Germantown, Philadelphia, Pa.

O

OAKS, Orion O. (*M* 1917), Chief Engr. (for mail), American Radiator Co., 40 West 40th St., New York, N. Y., and 119 Oak Ridge Ave., Summit, N. J.

O'BANNON, Lester Severance* (*M* 1928), Prof. of Heat Engrg., University of Kentucky, Lexington, Ky.

OBERT, Casin W. (*M* 1916), Consulting Engr., Union Carbide & Carbon Research Lab., Thompson Ave. and Manley St., Long Island City, and (for mail), 122 N. Columbus Ave., Mt. Vernon, N. Y.

O'BRIEN, J. H. (*M* 1923), Dist. Mgr., American Blower Corp., 228 N. La Salle St., Chicago, Ill.

O'CONNELL, Edward D. (*A* 1925), 1432 North 53rd St., Philadelphia, Pa.

O'CONNELL, Michael* (*J* 1927), 1722 Crosby Ave., New York, N. Y.

O'CONNELL, Patrick M. (*A* 1928), Sales Engr., U. S. Radiator Corp., 1401 Builders Bldg., and (for mail), 6325 N. Mozart St., Chicago, Ill.

O'CONNELL, Presly M. (*M* 1916), 5749–31st Ave. N. E., Seattle, Wash.

O'CONNOR, Joseph M. (*M* 1923), 1100 E. Douglass Ave., Wichita, Kan.

O'DONNELL, Thomas J. (*M* 1920), Secy-Treas. (for mail), William H. McKiever, Inc., 247 West 13th St., New York, and 927 Central Ave., Woodmere, L. I., N. Y.

ODROBINA, Stephen R. (*M* 1927), Engr., Vapor Engrg. Co., 489 Fifth Ave., New York, and (for mail), 25-33–36th St., Long Island City, N. Y.

OFFEN, Ben (*M* 1928), Owner and Mgr., B. Offen & Co., 608 S. Dearborn St., Chicago, Ill.

OFFNER, Alfred J. (*M* 1922), 1182 Broadway, New York, N. Y.

OLSEN, Carlton F. (*A* 1925; *J* 1920), 6238 Evans Ave., Chicago, Ill.

OLSON, Arvid E. (*M* 1925), 3554 Dickens Ave., Chicago, Ill.

OLSON, Bernhard (*A* 1929), General Appliance Sales Corp., 116 S. Michigan Ave., Chicago, Ill.

OLSON, Robert G. (*M* 1923), Br. Mgr. (for mail), American Blower Corp., 1418-19 Majestic Bldg., and 260 E. Wells St., Milwaukee, Wis.

OLVANY, William J. (*M* 1912), 100 Charles St., New York, N. Y.

O'NEILL, James W. (*M* 1929; *A* 1927; *J* 1925), Chief Engr. (for mail), Trane Co. of Canada, Ltd., 439 King St. W., and 8 Springmount Ave., Toronto, Ont., Can.

O'NEILL, Peter (*M* 1920), 224 Third Ave., Pittsburgh, Pa.

ORMSBY, H. Kingsley, Jr. (*J* 1928), Dist. Repr., Hoffman Specialty Co., 1538 E. Genesee St., Syracuse, N. Y.

ORR, Fred B. (*M* 1924), Illinois Maintenance Co., 72 W. Adams St., Chicago, Ill.

ORR, H. B. (*M* 1928), Mgr. (for mail), York Htg. & Vtg. Corp., 2323-24 Koppers Bldg., and 281 Lebanon Ave., Mt. Lebanon, Pittsburgh, Pa.

ORR, Merrill J. (*M* 1917), 513 Jackson St., Sioux City, Iowa.

ORTH, John W. (*M* 1919), 509 Columbia St., Lafayette, Ind.

OSBORNE, G. H. (*M* 1922), 836 Pratt Ave., Outremont, Montreal, Que., Can.

OSBORNE, Maurice Machado (*M* 1925), Partner, Osborne & Powell, 755 Boylston St., and (for mail), 367 Beacon St., Boston, Mass.

OSBORNE, Wallace J. (*A* 1927), Domestic Engrg., 110 East 42nd St., New York, N. Y.

OSTRANDER, Lewis F. (*M* 1923), 701 Lake Dr., Milwaukee, Wis.

OTIS, Gerald E.* (*M* 1922), H. Nelson Corp., Moline, Ill.

OTT, O. W. (*M* 1925), Consulting Mech. Engr. (for mail), 1100 Washington Bldg., and 123 S. Virgil Ave., Los Angeles, Calif.

OTTO, R. W. (*M* 1912), Mech. Engr., Toltz, King & Day, Builders Exchange, and (for mail), 2147 Carroll Ave., St. Paul, Minn.

OVERTON, Sidney Harold (*M* 1929), Consulting Engr., 65 Caroline St., South Yarra, Melbourne, Victoria, Australia.

P

PADGINTON, George (*M* 1919), 73 Huntington Ave., Buffalo, N. Y.

PAETZ, Herbert E. (*M* 1922), American Blower Co., 2539 Woodward Ave., Detroit, Mich.

PAGE, Harry W. (*M* 1923), 119 Warren Ave., Wauwatosa, Wis.

PAINE, Kenneth A. (*A* 1928; *J* 1925), Paine Htg. Co., 127 S. State St., Jackson, Miss.

PAINTER, David H. (*A* 1924), 4936 Park, Pkwy. Sta., Kansas City, Mo.

PARKER, Philip (*M* 1915), 8 Middle St., Woburn, Mass.

PARKHILL, David (*M* 1915), 116 Wooster St., New York, N. Y.

PARKS, W. N. (*A* 1927), Mgr. (for mail), U. S. Radiator Corp., 688 Hampden Ave., St. Paul, and 5348 First Ave. S., Minneapolis, Minn.

PARROTT, Lyle George (*M* 1922), Supervising Engr., Member of Firm (for mail), McColl, Snyder & McLean, 2304 Penobscot Bldg., and 3788 Gladstone Ave., Detroit, Mich.

PARTER, Samuel C. (*M* 1909; *J* 1907), Secy., James H. Merritt & Co., 207 Water St., and (for mail), 865 West End Ave., New York, N. Y.

PARTLAN, James W. (*M* 1916), (for mail), 14290 Goddard Ave., and 2521 Edison Ave., Detroit, Mich.

PATERSON, Frederick C., Jr. (*J* 1928), Paterson & Fensel, City Bldg., Bradford, Pa.

PATERSON, James S.* (*M* 1922), Board of Education, 155 College St., Toronto, Ont., Can.

PATORNO, Sullivan A. S. (*M* 1923), Meyer, Strong & Jones, Inc., 101 Park Ave., New York, N. Y.

PATRICK, Horace M. (*J* 1929), Mensing & Co., 1712 Chestnut St., Philadelphia, Pa.

PATTERSON, D. Finley (*J* 1923), Vapor Htg. Co., 2129 Cherry St., Philadelphia, Pa.

PATTON, Roy L. (*M* 1927), Pres. (for mail), Southwest Htg. & Plbg. Co., 1616 Petroleum Bldg., and 1111 West 38th St., Oklahoma City, Okla.

PAULDING, Lewis G. (*M* 1926), Treas. (for mail), Frank Paulding & Son, 4735 Grand Central Terminal Bldg., New York, and 8786 116th St., Richmond Hill, N. Y.

PAULSEN, Carl E. (*A* 1926), Mann & Co., 722 Rorabaugh-Wiley Bldg., Hutchinson, Kans.

PEACOCK, James K. (*M* 1921), Hoffman Specialty Co., 25 West 45th St., New York, N. Y.

PEAK, Alexander M. (*A* 1929; *J* 1927), 7221 North 21st St., Philadelphia, Pa.

PEARCE, C. E. (*M* 1911), 1255 Clinton Pl., Elizabeth, N. J.

PEASE, Harrison H. (*A* 1922), Carrier Engrg. Co., 39 W. Cortlandt St., New York, N. Y.

PECKHAM, Randolph R. (*M* 1919), c/o R. P. Peckham, 650 Baltimore W., Detroit, Mich.

PEEBLES, John K., Jr. (*A* 1925; *J* 1924), Peebles & Ferguson, 733 Law Bldg., Norfolk, Va.

PENCE, M. D. (*J* 1927), Asst. Engr. (for mail), C. A. Dunham Co., 450 E. Ohio St., and 7850 Saginaw St., Chicago, Ill.

PENNELL, S. Howard (*M* 1925), Member of Firm (for mail), William Macy Stanton, Architect, Land Title Bldg., and Lansdowne, Pa.

PENNOCK, William Britton (*M* 1927), Mgr. and Sales Engr. (for mail), Darling Bros., Ltd., 68½ Pitt St. W., and 1428 Victoria Ave., Windsor, Ont., Can.

PERHAM, Stanley H. (*M* 1920), Consulting Engr., 4507 Carrollton Ave., Indianapolis, Ind.

PERKINS, Fred C. (*A* 1923), Perkins Le Noir Co., 1068 Drexel Bldg., Philadelphia, Pa.

PERLSTEIN, Samuel (*J* 1928), 718 W. State St., Trenton, N. J.

PETERKIN, Stuart MacC. (*M* 1922), 71 Deloraine Ave., Toronto, Ont., Can.

PETERSON, Leslie James (*A* 1929), Sales Mgr. (for mail), Yelton Weaver Supply Co., 215 N. Eighth St., and 1112 Fayette Ave., Springfield, Ill.

PETHERICK, David H. (*A* 1916), 9 Kemberton Dr., Pleasant Ridge, Mich.

PFEIFFER, Benjamin J. (*A* 1919; *J* 1925), 435 West 41st St., New York, N. Y.

PFEIFFER, J. Frederick (*J* 1925), Htg. and Vtg. Engr., E. Keeler Co., and (for mail), 346 Louisa St., Williamsport, Pa.

PFUHLER, John L. (*A* 1925; *J* 1923), 600 Manor Rd., West New Brighton, S. I., N. Y.

PHELPS, Harold R. (*J* 1927), 960 Gladstone Apt. 405, Detroit, Mich.

PHILLIPS, Frank T. (*M* 1919), American Radiator Co., 2212 Walnut St., Philadelphia, Pa.

PHILLIPS, Frederic W., Jr. (*M* 1921), Engr. (for mail), E. W. Mandeville, Inc., 623 Parkside Ave., and 825 East 38th St., Brooklyn, N. Y.

PICKER, Frederick Charles (*A* 1926), Pres. (for mail), Air Conditioning & Engrg. Co., 2914 S. Jefferson Ave., and 4568 Tower Grove Pl., St. Louis, Mo.

PICKETT, Clinton A. (*A* 1923), Herman Nelson Corp., 200 Rialto Bldg., St. Louis, Mo.

PIERCE, Edward F., Jr. (*J* 1925), Sales Engr., Hoffman Specialty Co., Waterbury, Conn., and (for mail), 72 Pkwy, Melrose, Mass.

PIHLMAN, A. A. (*M* 1928), (for mail), Consolidated Gas Co., 4 Irving Pl., New York, N. Y., and 235 Dwight St., Jersey City, N. J.

PINDER, Percy H. (*M* 1919), 366 Third Ave., New York, N. Y.

PINE, Melvin (*M* 1929), Vice-Pres. (for mail), The Pine Engrg. Corp., 162-24 Jamacia Ave., and 181-11–90th Ave., Jamaica, N. Y.

PINES, Sidney (*M* 1920), Asst. Mgr. (for mail), Natkin Engrg. Co., 314-318 W. Tenth St., and 736 Valentine Rd., Kansas City, Mo.

PITCHER, Lester J. (*A* 1928; *J* 1924), 1518 East 69th St., Chicago, Ill.

PITTELKOW, Arthur G. (*M* 1907), Pres., Pittelkow Htg. & Engrg. Co., 2340 W. Lafayette Blvd., Detroit, Mich.

PIZIE, Stuart G. (*A* 1926), B. J. Pizie & Son, Millbrook, N. Y.

PLACE, Clyde R. (*M* 1924), Consulting Engr. (for mail), 420 Lexington Ave., and 333 East 57th St., New York, N. Y.

PLACE, Herman R. (*M* 1924), 835 Watertown St., West Newton, Mass.

PLAENERT, Alfred Bernhard (*J* 1927), 1114 S. Park St., Madison, Wis.

PLASS, Charles Webster (*M* 1928), Pres. (for mail), Plass Engrg. Corp., 1531 Grand Ave., and 426 East 55th St., Kansas City, Mo.

PLAYFAIR, George Alexander (*A* 1924), Mgr. (for mail), Johnson Temperature Regulating Co. of Canada, Ltd., 100 Adelaide St. E., and 78 Wineva Ave., Toronto, Ont., Can.

PLEWES, Stanley E. (*M* 1917), 2853 North 12th St., North Philadelphia, Sta. 8, Philadelphia, Pa.

PLUNKETT, John H. (*M* 1925), Chief of Inspection, Dept. of Public Safety, Massachusetts Commonwealth, State House, Room 24, Boston, and (for mail), 81 Woodrow Ave., Dorchester, Mass.

POCOCK, Paul C. (*M* 1929), N. E. Mgr. (for mail), York Htg. & Vtg. Corp., 260 Tremont St., Boston, and 8 Upland Rd., Wellesley, Mass.

POEHNER, Robert E. (*M* 1928), Vice-Pres. and Secy., W. H. Johnson & Son Co., 330 E. St. Joe St., and (for mail), 2308 Coyner Ave., Indianapolis, Ind.

POLDERMAN, L. H. (*M* 1927), Pacific Coast Mgr. (for mail), Carrier Engrg. Corp., 748 E. Washington St., and 1330 Colorado Blvd., Los Angeles, Calif.

POOL, Sterling H. (*M* 1913), 22 Market St., Lynn, Mass.

POOLE, Ernest F. (*M* 1921), Engr. (for mail), F. P. Sheldon & Son. 1009 Hospital Trust Bldg., and 74 Farragut Ave., Providence, R. I.

POPE, S. Austin (*M* 1917), 260 Jefferson St., Chicago, Ill.

POPE, William A. (*M* 1906), (for mail), 26 N. Jefferson St., Chicago, and 612 Keystone Ave., River Forest, Ill.

PORTRUDE, W. M. (*J* 1926), Salesman, Andersen, Meyer & Co., Ltd., Shanghai, China.

PORZEL, Joseph (*A* 1929), Vice-Pres. and Director of Research, Multicell Radiator Corp., West Ave., and (for mail), 593 East Ave., Lockport, N. Y.

POSEY, James (*M* 1919), 201 W. Franklin St., Baltimore, Md.

POWERS, Fred I. (*M* 1920), Factory Repr. (for mail), Box 324, and 605 S. Sixth Ave., Bozeman, Mont.

POWERS, F. W. (*M* 1911), Pres. and Gen. Mgr. (for mail), The Powers Regulator Co., 2720 Greenview Ave., and 900 Castlewood Ter., Chicago, Ill.

PRENTICE, Oliver J. (*A* 1927), Publicity Mgr. (for mail), C. A. Dunham Co., 450 E. Ohio St., and 850 Lake Shore Dr., Chicago, Ill.

PRESDEE, Cliff W. (*A* 1926), National Trade Journals, 521 Fifth Ave., New York, N. Y.

PRICE, William H., Jr. (*M* 1927), Sales Mgr., Air Conditioning Div., York Htg. & Vtg. Corp., 1541 Sansom St., Philadelphia, and (for mail), Windsor Ave., Wayne, Pa.

PROBST, A. H. (*M* 1919), Morgan-Gerrish Co., 800-6 La Salle Ave., Minneapolis, Minn.

PROHASKA, Ernest C. (*A* 1929), 1752 N. Monticello Ave., Chicago, Ill.

PROX, Robert F. (*M* 1923; *J* 1922), Vice-Pres. (for mail), Frank Prox Co., 1201 S. First St., and 1608 S. Fourth St., Terra Haute, Ind.

PRYOR, Frederick L. (*M* 1913), National Silk Dyeing Co., 5 Colt St., Paterson, N. J.

PRYOR, Robert W., Jr. (*M* 1913), (Council, 1919-1920), Mech. Engr. (for mail), Koithan & Pryor, 39 Cortlandt St., New York, N. Y., and 199 Roseville Ave., Newark, N. J.

PURCELL, Arthur J. (*M* 1914), Engr. Salesman, 631 New Britain Ave., Hartford, Conn.

PURCELL, Frederick C. (*M* 1926), 2847 Grand River Ave., Detroit, Mich.

PURCELL, Robert E. (*M* 1916), 1726 Willis Ave., Detroit, Mich.

PURDY, Alexander K. (*M* 1922), Purdy Mansell, Ltd., 63 Albert St., Toronto, Ont., Can.

PURDY, Randall B. (*A* 1927), McGraw-Hill Publishing Co., Tenth Ave. and 36th St., New York, N. Y.

PURINTON, Dexter J. (*A* 1923), 101 Park Ave., New York, N. Y.

PURSELL, H. E. (*M* 1919), Kewanee Boiler Co., and (for mail), 212 S. Tremont St., Kewanee, Ill.

PYLE, J. W. (*M* 1919), Mgr. (for mail), Peru Htg. Co., 28-30 W. Canal St., and 371 W. Third St., Peru, Ind.

Q

QUALTROUGH, B. F. (*A* 1926), 928 Wyandotte St., Kansas City, Mo.

QUAY, D. M. (*Charter Member; Presidential Member*), (Pres., 1900; 1st Vice-Pres., 1896, 1899; 2nd Vice-Pres., 1895), Builders Exchange, Cleveland, O.

QUENTIN, Edward H. (*A* 1919), 2328 Locust St., St. Louis, Mo.

QUIGLEY, William J. (*M* 1920), 27 Knowlton Ave., Hertal Sta., Buffalo, N. Y.

QUIRK, Clinton H. (*M* 1916; *J* 1915), Sales Engr., Vento and Arcoblast Div. (for mail), American Radiator Co., 40 West 40th St., New York, and 36 Kilburn Rd., Garden City, N. Y.

R

RAE, Thomas W. (*M* 1924), American Radiator Co., P. O. Box 882, Oklahoma City, Okla.

RAINE, John J. (*M* 1912), G. S. Blodgett Co., Burlington, Vt.

RAINGER, Wallace F. (*J* 1924), Chief Draftsman, Jaros & Baum, 116 West 39th St., New York, and (for mail), 441 Hawthorne Ave., Yonkers, N. Y.

RAISLER, Samuel (*M* 1921), 173 Riverside Dr., New York, N. Y.

RALSTON, Louis T. M. (*M* 1926), Pres. (for mail), Louis T. M. Ralston, Inc., 52 Vanderbilt Ave., and 25 East 77th St., New York, N. Y.

RAMSAY, Harold Whiteman (*J* 1928), Newton Sq., Delaware County, Pa.

RANDALL, W. Clifton* (*M* 1928), Chief Engr. (for mail), Detroit Steel Products Co., 2250 E. Grand Blvd., and 5540 Ridgewood Ave., Detroit, Mich.

RANDOLPH, Charles H. (*A* 1928; *J* 1926), Kewanee Boiler Corp., 440 Barclay St., Milwaukee, Wis.

RASMUSSEN, Einar (*A* 1926; *J* 1925), 419 Whitney St., Wilkinsburg, Pa.

RATHER, Max F. (*M* 1919), Johnson Service Co., 2142 East 19th St., Cleveland, O.

REARDON, J. Albert (*M* 1921), Reardon Bros. Co., 341 Union St., Lynn, Mass.

RECH, P. D. (*A* 1927), Gen. Sales Dept. (for mail), Hoffman Specialty Co., Inc., P. O. Box 1220, Waterbury, and Main St., Watertown, Conn.

RECK, William Ernst (*M* 1927), Vice-Pres. (for mail), The Reck Htg. Co., 15 Esromgade, Copenhagen, and Sundvej 16, Hellerup, Denmark.

REDERER, Benedict S. (*M* 1922), (for mail), 611 Arrott Bldg., and 384 Avon Dr., Mt. Lebanon, Pittsburgh, Pa.

REED, John F. (*M* 1927; *A* 1923), Vice-Pres., Reed Air Filter Co., 420 Lexington Ave., New York, N. Y.

REED, William M. (*M* 1927), Reed Air Filter Co., 215 Central Ave., Louisville, Ky.

REEDER, Charles L. (*M* 1911), 916 N. Charles St., Baltimore, Md.

REESE, Henry L. (*M* 1923), Engr., 426 Jefferson St., Hyde Park, Reading, Pa.

REHLING, Hugo F. (*M* 1928), Dist. Mgr. (for mail), B. F. Sturtevant Co., 445 Penton Bldg., Cleveland, and 1212 Hathaway Ave., Lakewood, Ohio.

REID, Henry P. (*A* 1927), Special Engr. (for mail), Universal Portland Cement Co., Room 1520, 210 S. La Salle St., Chicago, and 3507 Oak Park Ave., Berwyn, Ill.

REILLY, Charles Edward (*J* 1928), 4920 City Line Ave., Philadelphia, Pa.

REILLY, J. Harry (*J* 1929), Htg. Engr., Kimball & Cucci, 205 East 42nd St., New York, N. Y., and (for mail), 14 Watson Ave., East Orange, N. J.

REPP, Harry L. (*M* 1922), 2294 Scranton Rd., Cleveland, Ohio.

RETTEW, Harvey F. (*M* 1929), Htg. and Vtg. Engr., Board of Public Education, 19th and Ludlow Sts., and (for mail), 6821 Martins Mill Rd., Philadelphia, Pa.

REUSS, Edward H., Jr. (*M* 1921; *A* 1919), 49th and Grays Ave., Philadelphia, Pa.

REYNOLDS, Henry M. (*M* 1915), P. O. Box 350, San Antonio, Tex.

REYNOLDS, Thurlow Weed (*M* 1922), Mech. Engr., American Radiator Co., 40 West 40th St., New York, N. Y., and (for mail), 62 Hackensack St., Woodridge, N. J.

REYNOLDS, Walter V. (*A* 1928), James-Reynolds Co., Inc., 218 East 42nd St., New York, N. Y.

RICE, C. J. (*A* 1923), Western Distributor, Modine Mfg. Co., 1626 Holton St., Milwaukee, Wis.

RICE, John A. (*A* 1929), Htg. and Vtg. Estimator, Thompson Starret Co., 245 Hunters Point Ave., Long Island City, and (for mail), 108 Locust Blvd., Gibson, L. I., N. Y.

RICE, William W. (*M* 1915), 830 Morgan Ave., Drexel Hill, Delaware County, Pa.

RICHARD, I. T. (*A* 1928), Steamfitter and Engr., J. G. Gillispie Co., 708 Columbia Rd., Dorchester, and (for mail), 27 Mt. Pleasant Ave., Roxbury, Mass.

RICHARDS, S. Frank (*M* 1915), Pres., The Richards Corp., 1125 North Ave., Wilkinsburg Br., Pittsburgh, and (for mail), 335 West Riverview Ave., Bellevue Br., Pittsburgh, Pa.

RICHARDSON, D. Rait (*M* 1915), Pres., Richardson & Boynton Co., 260 Fifth Ave., New York, N. Y.

RICHARDSON, Frank J. (*M* 1921), Mech. Engr., Board of Education, 131 Livingston St., and (for mail), 467 First St., Brooklyn, N. Y.

RICHTMANN, William Muir* (*J* 1926), 3104 Wells St., Apt. 101, Milwaukee, Wis.

RICKLY, Francis A. (*A* 1927), Special Repr. (for mail), American Radiator Co., 4201 Duncan Ave., and 5616 Pershing Ave., St. Louis, Mo.

RIES, Lester S. (*M* 1929), Supt. of Buildings and Grounds (for mail), University of Chicago, 5750 Ellis Ave., and 5514 University Ave., Chicago, Ill.

RIETZ, Elmer W. (*M* 1923), Asst. Sales Mgr. (for mail), Powers Regulator Co., 2720 Greenview Ave., Chicago, and 940 Greenwood Ave., Winnetka, Ill.

RILEY, Champlain L. (*M* 1906), (*Presidential Member*), (Pres., 1921; 1st Vice-Pres., 1920; Council, 1918-1922), Clark, MacMullen & Riley, 101 Park Ave., New York, N. Y.

RILEY, DeWitt H. (*M* 1921), Engr., American Radiator Co., Bond Plant, 87 Rano St., Buffalo, and (for mail), 88 Columbia Rd., Kenmore, N. Y.

RINKENBERGER, George (*M* 1924), 244 Market St., Johnstown, Pa.

RITCHIE, Edmund J. (*M* 1923), Sarco Co., 183 Madison Ave., New York, N. Y.

RITCHIE, William (*M* 1909), Vice-Pres., Boynton Furnace Co., 58 West 40th St., New York, N. Y., and (for mail), 17 Van Reipen Ave., Jersey City, N. J.

RITTER, Arthur (*M* 1911), Mgr. (for mail), American Blower Corp., 50 Church St., New York, and Edgemont Rd., Scarsdale, N. Y.

ROBB, John M. (*M* 1913), Director of Service, Herman Nelson Corp., Moline, and (for mail), 1513 Columbia Ter., Peoria, Ill.

ROBERTS, Henry L. (*M* 1916), Engr. and Contractor (for mail), 228 North 16th St., Philadelphia, and 1014 Allston Rd., Brookline, Delaware County, Pa.

ROBERTS, J. H. (*M* 1926), W. A. Case & Son Mfg. Co., 203 Woodbridge St. W., Detroit, Mich.

ROBERTSON, John M. (*A* 1927; *J* 1926), Br. Mgr. (for mail), E. K. Campbell Htg. Co., 4908 Delmar Blvd., and 6716 Clayton Ave., St. Louis, Mo.

RODMAN, Robert W. (*M* 1922), Supt. of Plant Operation (for mail), Board of Education, City of New York, 500 Park Ave., and 175 West 73rd St., New York, N. Y.

ROEBUCK, William, Jr. (*M* 1917), Partner (for mail), R. T. Coe Cos., 308 Jackson Bldg., and Linwood and Summer Sts., Buffalo, N. Y.

ROEMER, Julius (*M* 1928), Owner, J. Roemer Htg. Co., Builders Exchange, Cleveland, Ohio.

ROGERS, A. Carle (*M* 1921), Commissioner of Water, Div. of Water, City of Toledo, 110 Cherry St., and (for mail), 752 Euclid Ave., Toledo, O.

RONEY, Thomas G. (*M* 1916), 3461 Fort St. W., Detroit, Mich

ROONEY, Martin A. (*M* 1918; *A* 1917), Pierce, Butler & Pierce Mfg. Corp., 41 East 42nd St., New York, N. Y.

ROSEBROUGH, Robert M. (*M* 1920), Br. Mgr. (for mail), L. J. Mueller Furnace Co., 4246 Forest Park Blvd., St. Louis, and 7241 Dorset Ave., University City, St. Louis County, Mo.

ROSENBACH, Rudolph G. (*M* 1920), 549 Washington St., Chicago, Ill.

ROSENBERG, Philip (*A* 1928), 811 Walton Ave., New York, N. Y.

ROSS, John O. (*M* 1920), Pres., Ross Industries Corp., 271 Madison Ave., New York, N. Y.

ROSS, Joseph F. (*M* 1926), Secy-Treas. (for mail), Ross Boiler Co., 112 W. Adams St., Chicago, and 7501–57th St., Summit, Ill.

ROSSMAN, V. D. (*M* 1919; *A* 1907), 2365 Klemm St., St. Louis, Mo.

ROTHROCK, John T. (*M* 1920), Thompson-Starrett Co., Inc., 250 Park Ave., New York, N. Y.

ROTTMAYER, Samuel I. (*J* 1928), 918 Winona Ave., Chicago, Ill.

ROTZ, John M. (*M* 1918), (for mail), J. M. Rotz Engrg. Co., 704 Merchants Bank Bldg., Indianapolis, and Carmel, Ind.

ROWE, William A. (*M* 1921), (Council, 1929), Chief Engr. (for mail), American Blower Corp., 6004 Russell St., and 1733 Virginia Park, Detroit, Mich.

ROWLEY, Frank Benjamin* (*M* 1918), (Council, 1927-1929), Prof. of Mech. Engrg. and Director of Experimental Engrg. Lab., University of Minnesota, and (for mail), 63 Barton Ave. S. E., Minneapolis, Minn.

ROYER, Earl B. (*M* 1928), Des. Engr., Fosdick & Hilmer, 1703 Union Trust Bldg., and (for mail), 6635 Iris Ave., Cincinnati, Ohio.

RUDDELL, W. H. (*M* 1921), Mgr. (for mail), West Coast Htg. Co., Inc., 505 Lloyd Bldg., and 816 W. Blaine St., Seattle, Wash.

RUFF, DeWitt C. (*M* 1922), Healy-Ruff Co., 765 Hampden Ave., St. Paul, Minn.

RUGART, Karl (*A* 1924), Associate Mgr. (for mail), Warren Webster & Co., 301 Stephen Girard Bldg., and 5830 Willows Ave., Philadelphia, Pa.

RUGGLES, Robert F. (*A* 1927; *J* 1926), 15 Gregg Pl., Randall Manor, Tompkinsville, S. I., N. Y.

RUPPERT, E. H. (*A* 1923), 85 Eastern Pkwy., Brooklyn, N. Y.

RUSSELL, Edward A. (*A* 1927), 8103 Dorchester Ave., Chicago, Ill.

RUSSELL, Hugh C.* (*M* 1911), U. S. Treas. Dept., Post Office Bldg., Chattanooga, Tenn.

RUSSELL, Joseph N. (*M* 1899), 37 Duke St., Oxford St., London, W. 1, England.

RUSSELL, W. A. (*M* 1921), (for mail), U. S. Radiator Corp., 1405 West 11th St., and 235 Ward Pkwy., Kansas City, Mo.

RUSSELL, William Arthur (*Charter Member*), Pres., W. A. Russell & Co., Grand Central Terminal Bldg., New York, N. Y.

RUSSELL, William Bradford (*M* 1928), Colorado Ave., R. F. D. 1, Joliet, Ill.

RUSSELL, William L. A. (*A* 1925), Sales Mgr., Skinner Bros. Mfg. Co., Inc., 1474 S. Vandeventer Ave., and (for mail), 1246 Temple Pl., St. Louis, Mo.

RYAN, Harry J. (*M* 1922), Consulting Engr., 47 Harris Ave., Albany, N. Y.

RYDELL, C. A. (*J* 1928), Mech. Engr., Carrier-Lyle Corp., 850 Frelinghuysen Ave., and (for mail), 244 Roseville Ave., Newark, N. J.

RYEN, Max (*J* 1928), Pierce, Butler & Pierce, Nickols St., Syracuse, N. Y.

S

SABIN, Edward R. (*M* 1919), E. R. Sabin & Co., 4710-12 Market St., Philadelphia, Pa.

SACHLEBEN, Edward H. (*A* 1921), E. H. Sachleben & Co., 2829 Locust St., St. Louis, Mo.

SADLER, Charles Boone (*M* 1928), Design Draftsman (for mail), Public Works Office, 11th Naval Dist., and 4440 Point Loma Ave., San Diego, Calif.

ST. CLAIR, Charles W. (*J* 1927), Sales Engr. (for mail), Herman Nelson Corp., 321 Union Bldg., Cleveland, and 17225 Clifton Blvd., Lakewood, Ohio.

ST. JOHN, Joseph S. (*J* 1928), Secy-Treas. (for mail), Dexter Engrg. Co., 12508 Dexter Blvd., and 13138 Turner, Detroit, Mich.

SAITO, Shozo (*M* 1923), Htg. and Vtg. Contractor (for mail), 6th Floor, Marunouchi Bldg., and 171 Kits-kamata, Tokyo-fu, Japan.

SAKOUTA, Mathieu L. (*M* 1924), Gavan Simanskaia 4, Leningrad, Russia.

SAMUELS, Sidney (*A* 1928; *J* 1925), 262 West 145th St., New York, N. Y.

SANBERN, E. Nute* (*M* 1923), Engr. (for mail), Mensing & Co., 928 Presser Bldg., Philadelphia, Pa., and 119 S. Haviland Ave., Audubon, N. J.

SANDS, Clive Chisholm (*M* 1929), Briton Ltd., Dowling St., Waterloo, Sydney, Australia.

SANFORD, Arthur L. (*M* 1915), Mech. Engr. (for mail), Board of Education, 245 Ninth Ave. N., and 301 East 48th St., Minneapolis, Minn.

SAULSON, Saul (*M* 1916), Mech. Engr. (for mail), A. Kahn, Inc., 1000 Marquette Bldg., and 12524 Broadstreet Ave., Detroit, Mich.

SAUNDERS, J. Chester (*M* 1926), Estimator and Engr. (for mail), Crosby & Beard Co., 1550 S. Wabash Ave., and 10921 Oakley Ave., Chicago, Ill.

SAVILLE, Thomas H. (*M* 1924), 2009 N. Wabash Ave., and 1121 Lafayette St., Scranton, Pa., and (for mail), c/o Dean D. E. Carpenter, International Correspondence School, Scranton, Pa.

SAWADE, Carl A. (*A* 1920), Mgr. Sales Planning (for mail), National Radiator Corp., 55 West 42nd St., New York, and 569 Webster Ave., New Rochelle, N. Y.

SAWDON, Will M. (*M* 1920), Prof. Experiment Engrg. (for mail), Cornell Iniversity, and 1018 E. State St., Ithaca, N. Y.

SAWHILL, R. V. (*A* 1929), Engineering Publications, Inc., 1900 Prairie Ave., Chicago, Ill.

SCHANK, George E. (*A* 1926), 155–16th St., Buffalo, N. Y.

SCHANZE, Augustus Gale (*A* 1925), Mgr., Hardinge Oil Burner Corp., 843 Beacon St., Boston, and (for mail), 30 Willoughby St., Brighton, Mass.

SCHEER, Frederick W. (*M* 1922), 430 Connecticut, Buffalo, N. Y.

SCHEIBEL, Albert H. (*M* 1919), 92 Milton Ave., Hyde Park, Mass.

SCHEIDECKER, Daniel B. (*A* 1919), Hunter-Clark Vtg. System, 2800 Cottage Grove Ave., Chicago, Ill.

SCHELLHAMMER, Alfred L. (*M* 1919), Pennsylvania Furnace & Iron Co., Warren, Pa.

SCHIMMEL, F. W. (*M* 1926), Warren Webster & Co., 279 Cumberland St., Harrisburg, Pa.

SCHLEY, Arthur A. (*M* 1920), Schley & Nash Co., 709 Columbia Bk. Bldg., Pittsburgh, Pa.

SCHLOSS, Newton L. (*M* 1913), Consulting Engr. (for mail), 51 East 42nd St., New York, and 347 Lincoln Pl., Brooklyn, N. Y.

SCHMIDT, George G. (*M* 1914; *J* 1912), Secy. (for mail), Carrier-Lyle Corp., 39 Cortlandt St., New York, and 55 Burns St., Forest Hills, L. I., N. Y.

SCHNEIDER, Charles (*M* 1923), 492 East 163rd St., New York, N. Y.

SCHNEIDER, Paul W. (*M* 1919), 305 La Fayette St., Utica, N. Y.

SCHOENIJAHN, Robert Polk (*M* 1919), Consulting Engr. (for mail), 406-8 Industrial Trust Bldg., and 719 Nottingham Rd., Wilmington, Del.

SCHOEPFLIN, Paul H. (*M* 1920), Pres. (for mail), Niagara Blower Co., 95 Liberty St., New York, and 91 Valley Rd., Larchmont, N. Y.

SCHOFIELD, Thomas Johnson (*M* 1928), Gen. Mgr., Schofield-Cowl Co., 23 Tenth St., and Glenwood Heights, Wheeling, W. Va.

SCHOPP, Walter J. (*M* 1922), Designer, United Engineers & Constructors, Inc., 1401 Arch St., Philadelphia, Pa., and (for mail), 711 Lincoln Ave., Palmyra, N. J.

SCHRADER, Charles C.* (*A* 1925; *J* 1923), Research Engr., Armstrong Cork Co., Research Div., Lancaster, Pa.

SCHRAM, Waldo W. (*M* 1928), Supervisor Htg. Div. (for mail), Northern Indiana Public Service Co., 649 Hohman St., and 109–15th Ave., Hammond, Ind.

SCHROTH, A. H. (*M* 1911), Vice-Pres., Richmond Radiator Co., 1480 Broadway, New York, N. Y., and (for mail), 90 S. Oraton Pkwy., East Orange, N. J.

SCHUKAI, Walter (*J* 1928), Estimator (for mail), Eichler Htg. Co., Railway Exchange Bldg., and 5208-A Von Phul St., St. Louis, Mo.

SCHULZ, Howard I. (*A* 1915), 1217 W. Broad St., Richmond, Va.

SCHULZE, Benedict H. (*M* 1921), Sales Engr. (for mail), Hester Bradley Co., 4200 Forest Park Blvd., and 416 Alta Dena Court, St. Louis, Mo.

SCHUNK, Thomas (*M* 1929), Htg. Engr., Baker Bros. & Co., Riverhead, and (for mail), Quogue, N. Y.

SCHWAB, Henry E. (*M* 1923), Vice-Pres. (for mail), R. J. Schwab & Sons Co., 283 Clinton St., Milwaukee, Wis.

SCHWAB, Quentin D. (*J* 1927), Htg. and Vtg. Engr. (for mail), C. A. Dunham Co., 450 E. Ohio St., Chicago, Ill., and 570 Buchanan St., Gary, Ind.

SCHWARTZ, Jacob (*J* 1929), Estimator, Samuel Schwartz, 30 West 27th St., Bayonne, N. J.

SCHWEIM, Henry J. (*M* 1928), Development Engr. (for mail), United States Gypsum Co., 300 W. Adams St., Chicago, and 2233 Forest View Rd., Evanston, Ill.

SCOLLAY, Ulysses G. (*Charter Member*), (Treas., 1904; 1911; Council, 1894-1904-1911; Board of Managers, 1895), 308 Halsey St., Brooklyn, N. Y.

SCOTT, Charles E. (*M* 1907), Pres. and Treas. (for mail), Vapor Engrg. Co., 489 Fifth Ave., New York, N. Y., and Meadowbrook Rd., Darien, Conn.

SCOTT, Clarence E. (*A* 1929; *J* 1926), Air Conditioning Engr. (for mail), York Htg. & Vtg. Corp., 1541 Sansom St., Philadelphia, and 730 Wynnewood Rd., Ardmore, Pa.

SCOTT, Edwin A. (*M* 1912), E. A. Scott Publishing Co., 45 West 45th St., New York, N. Y.

SCOTT, George McKay (*M* 1915), 108 Wooster St., New York, N. Y.

SEELING, Alfred E. (*M* 1926), Pres. and Gen. Mgr., L. J. Wing Mfg. Co., 154 West 14th St., and (for mail), 310 Convent Ave., New York, N. Y.

SEELIG, Lester (*M* 1925), Mech. Engr., Drying Systems, Inc., 1800 Foster Ave., and (for mail), 2600 N. Kedzie Ave., Chicago, Ill.

SEIDERS, John T. (*M* 1926), 82 S. High St., Room 214, Columbus, O.

SEITER, J. Earl* (*M* 1928), Asst. Mgr. New Business Dept., Steam Sales, Consolidated Gas, Elec. Light & Power Co. of Baltimore, Lexington Bldg., Baltimore, and (for mail), 6 Dixie Dr., Towson, Md.

SEKIDO, Kunisuke (*M* 1903), Consulting Engr., 885 Marunouchi Bldg., Tokyo, and (for mail), 3300 Nakano, Tokyo Suburb, Japan.

SELIG, Ernest T. (*M* 1926), Consulting Engr. (for mail), 1501 Herr St., and 920 North 16th St., Harrisburg, Pa.

SELLARS, Fred J. (*M* 1917), 311 N. Penn Ave., Independence, Kan.

SELLMAN, Nils T. (*M* 1922), Asst. Secy. (for mail), Consolidated Gas Co., 4 Irving Pl., and 135 West 183rd St., New York, N. Y.

SELTZER, A. P. (*M* 1921), Sales Engr. (for mail), American Radiator Co., 820 S. Michigan Ave., Chicago, and Evanshire Hotel, Evanston, Ill.

SENIOR, Richard L. (*M* 1925), Engr. and Supt., J. Gescheidt & Co., Inc., 142 East 43rd St., New York, and (for mail), 1 Edgewater Pl., Dillon Park, New Rochelle, N. Y.

SETZER, Walter C. (*A* 1926; *J* 1922), N. W. Cor. Gillham St. and Hasbrook Ave., Lawndale, Philadelphia, Pa.

SEWARD, Percival H. (*Charter Member*), 369 Washington Ave., Brooklyn, N. Y.

SEWELL, John M. (*M* 1919), (for mail), Marine-Galligan Co., 14 South 20th St., Philadelphia, and Warren Ave., Berwyn, Pa.

SHANKLIN, Arthur P. (*M* 1929), 1724 Land Title Bldg., Philadelphia, Pa.

SHANKLIN, Jno. A. (*M* 1928), Estimator (for mail), West Virginia Htg. & Plbg. Co., 233 Hale St., and 5 Swathmore Ave., Charleston, W. Va.

SHANKLIN, John R. (*M* 1899), Pres. and Gen. Mgr. (for mail), West Virginia Htg. & Plbg. Co., 233 Hale St., and 1506 Quarrier St., Charleston, W. Va.

SHARP, Floyd H. (*M* 1929), Contracting Htg. Engr. (for mail), Chatfield & Sharp, 304 Pine St., and 512 E. Seventh, Jamestown, N. Y.

SHAVER, Herbert H. (*A* 1929), Asst. Gen. Sales Agent (for mail), The Hudson Coal Co., 424 Wyoming Ave., and 215 Wheeler Ave., Scranton, Pa.

SHAW, Edgar (*M* 1923), Pres. (for mail), Lynch & Woodward, Inc., 320 Dover St., Boston, and 51 Royal St., Wollaston, Mass.

SHAW, N. J. H. (*M* 1927; *J* 1925), 15 Silk St., Arlington, Mass.

SHAW, R. E. (*M* 1921), Sales Mgr. (for mail), B. F. Sturtevant Co., Hyde Park, Boston, and Wellesley Hills, Mass.

SHAY, Russell A. (*M* 1924), 108 Linwood St., Brooklyn, N. Y.

SHEARS, Matthew W. (*M* 1922), 53 Sylvan Ave., Toronto, Ont., Can.

SHEFFIELD, Edward B. (*M* 1921), Sales Engr., Armstrong Cork & Insulation Co., 11 Brant St., Toronto, Ont., Can.

SHEFFLER, Morris (*M* 1921), Pres. (for mail), Sheffler-Gross Co., Inc., 203-11 Drexel Bldg., and 5451 Lebanon Ave.,' Philadelphia, Pa.

SHELDON, Nelson E. (*M* 1927), Dist. Mgr. (for mail), York Htg. & Vtg. Corp., 703 Temple Bldg., and 942 Genesee Park Blvd., Rochester, N. Y.

SHEPPARD, F. A. (*M* 1918), Salesman (for mail), Johnson Service Co., 411 E. Tenth St., and 27 East 70th St., Kansas City, Mo.

SHEPPARD, William G. (*M* 1922), Sheppard & Abbott, 119 Harbour St., Toronto, Ont., Can.

SHEPSTONE, Oscar (*M* 1927), Engr., Detroit Edison Co., 2000 Second Ave., and (for mail), 121 N. Phillip Ave., Detroit, Mich.

SHERET, Andrew (*M* 1929; *A* 1925), Pres. (for mail), Andrew Sheret, Ltd., 1114 Blanshard St., and 1030 St. Charles St., Victoria, B. C.

SHERRY, Raymond Wilbur (*M* 1927), 601 Peace St., Hazelton, Pa.

SHINOHARA, Shiro (*M* 1924), Z. Chome Kojimachi, Kojimachikes, Tokyo, Japan.

SHIPP, C. C. (*M* 1923), Owner, C. C. Shipp & Co., 230 E. Ohio St., Room 210, Indianapolis, Ind.

SHODRON, John G. (*M* 1921), 411 E. Milwaukee Ave., Ft. Atkinson, Wis.

SHORB, Will A. (*M* 1909), 3 Lincoln Pl., Decatur, Ill.

SHREINER, Dewey C. (*A* 1926; *J* 1923), Vice-Pres. and Treas. (for mail), Shreiner & Son, Inc., 116 W. High St., and 1240 S. Boulevard, Elkhart, Ind.

SHROCK, J. H. (*M* 1924), Vice-Pres. (for mail), New York Blower Co., and 1524 Michigan Ave., La Porte, Ind.

SHRUM, A. T. (*M* 1928), 712 Louisville Trust Bldg., Louisville, Ky.

SHUELL, Frank W. (*A* 1921), Pres. and Gen. Mgr. (for mail), Ever Hot Heater Co., 5241 Wesson Ave., Detroit, and Lone Pine Rd., Bloomfield Hills, Mich.

SHUFELT, Howard M. (*A* 1928), 7353 Bennett Ave., Chicago, Ill.

SHULTZ, Earle (*A* 1919), Vice-Pres. (for mail), Illinois Maintenance Co., 1136-72 W. Adams St., and 1310 Birchwood Ave., Chicago, Ill.

SIEBS, Claude T. (*A* 1927), Western Elec. Co., 100 Central Ave., Kearny, N. J.

SIEGEL, Leo (*M* 1928; *A* 1925; *J* 1924), Mech. Engr., Board of Education, Bridge and Concord Sts., and 1901 Stillwell Ave., Brooklyn, N. Y.

SIMONDS, A. H. (*J* 1929), Sales Engr. (for mail), Carrier Engrg. Corp., 748 E. Washington St., and 446 Westminster St., Los Angeles, Calif.

SIMPSON, William A. (*M* 1925), Johnson & Morris, 538 West 23rd St., New York, N. Y.

SIMPSON, William K. (*M* 1919), Secy. (for mail), Hoffman Specialty Co., and 9 Sands St., Waterbury, Conn.

SKAGERBERG, R. (*M* 1924; *J* 1921), Consulting Engr., 1497 Chelmsford St., St. Paul, Minn.

SKELLY, John F. (*M* 1921), 303 Catherine St., Ogdensburg, N. Y.

SKINNER, H. W. (*M* 1920), Mech. Engr. (for mail), Wyatt C. Hedrick, Inc., 1005 First National Bk. Bldg., and 1901 Tremont St., Ft. Worth, Tex.

SKLENARIK, Louis (*J* 1928), Thompson-Starrett Co., 245 Hunters Point Ave., Long Island City, N. Y.

SLIGHT, Irvin (*A* 1925), Partner (for mail), Slight Bros., 741 Yorkway Pl., Jenkintown, and Hartsville, Pa.

SMALL, John D. (*M* 1910), 940-127 N. Dearborn St., Chicago, Ill.

SMALLMAN, Edwin W. (*M* 1920), Engr., Stone & Webster Engrg. Corp., 49 Federal St., Boston, and (for mail), 21–13th St., Melrose, Mass.

SMALLMAN, William T. (*Life Member; M* 1911), Treas. (for mail), Isaac Coffin Co., 52 Sudbury St., and 127 Rockland Ave., Malden, Mass.

SMITH, Gard Wentworth (*M* 1927), 6900 E. Jefferson Ave., Detroit, Mich.

SMITH, Harold Paul (*M* 1928), Mgr., The H. Smith Co., De Normandie Ave., Fair Haven, N. J.

SMITH, John Colbourne (*A* 1929; *J* 1927), Sales Engr., Niagara Blower Co., 673 Ontario St., Buffalo, and (for mail), 95 Columbia Blvd., N. Y.

SMITH, Leslie L.* (*M* 1919), Smith, Hinchman & Grylls, 800 Marquette Bldg., Detroit, Mich.

SMITH, Milton S. (*M* 1919), Vice-Pres., Carrier Engrg. Corp., 850 Frelinghusyen Ave., Newark, and (for mail), 13 N. Terrace, Maplewood, N. J.

SMITH, Philip C., Jr. (*M* 1928), Northport, L. I., N. Y.

SMITH, Russell J. (*A* 1929), Sales Engr., 2228 Washington Ave., St. Louis, Mo.

SMITH, Sidney S. (*M* 1926), Andes Range & Furnace Co., Geneva, N. Y.

SMITH, Virgil A. (*A* 1927; *J* 1923), 2304 Cleveland Ave., Tampa, Fla.

SMITH, Wilbur F. (*M* 1920), 422 Bryn Mawr Ave., Cynwyd, Pa.

SNELL, Ernest (*M* 1920), 3914 Le May Ave., Detroit, Mich.

SNIDER, L. A. (*M* 1927), Pres. (for mail), L. A. Snider Engrg. Service, Inc., 612 N. Michigan Ave., and 814 Sunnyside Ave., Chicago, Ill.

SNYDER, Jay W. (*M* 1917), McColl-Snyder-McLean, 2348 Penobscott Bldg., Detroit, Mich.

SNYDER, Joseph S. (*A* 1925), Special Repr., American Radiator Co., 374 Delaware Ave., and (for mail), 39 Granger Pl., Buffalo, N. Y.

SODEMANN, Paul W. (*M* 1926; *A* 1925; *J* 1920), 4947 Cote Brilliante Ave., St. Louis, Mo.

SODEMANN, William C. B. (*M* 1919), Pres. (for mail), Sodemann Htg. & Power Co., 2306 Morgan St., and 3510-A University St., St. Louis, Mo.

SODERBERG, C. H. (*M* 1919), Consulting Engr. (for mail), 606 Donovan Bldg., Detroit, and 672 Puritan Rd., Birmingham, Mich.

SOMERS, William Stuart (*M* 1928; *J* 1926), 2807 Grand Ave., Des Moines, Ia.

SOMMER, Louis J., Jr., (*M* 1922), Pres. (for mail), Louis J. Sommer & Son, Inc., 2436 Brown St., Philadelphia, Pa.

SOPER, Horace A. (*M* 1916), Vice-Pres. (for mail), American Foundry & Furnace Co., and 1122 E. Monroe St., Bloomington, Ill.

SOPER, Ira N. (*M* 1919), Warren Webster & Co., 549 W. Washington Blvd., Chicago, Ill.

SOULE, Lawrence C. (*M* 1908), Secy. and Chief Engr.. (for mail), Aerofin Corp., 850 Frelinghuysen Ave., Newark, and Gordon and Stewart Rds., Essex Fells, N. J.

SOWERS, Paul E. (*M* 1922), Engr.-Mgr. (for mail), Paul E. Sowers Co., 25 N. Duke St., and 110 N. Finlay St., York, Pa.

SPAFFORD, Allen (*A* 1927), Factory Supt. (for mail), Wood Conversion Co., and 406 Ave., D, Cloquet, Minn.

SPAFFORD, Lewis Burton (*A* 1929), Engrg. Editor (for mail), Htg., Piping and Air Conditioning, 1900 Prairie Ave., Chicago, Ill., and Buchanan, Mich.

SPECKMAN, Charles H. (*M* 1918), 375 The Bourse, Philadelphia, Pa.

SPELLER, Frank N.* (*M* 1908), Dir., Dept. of Metallurgy and Research (for mail), National Tube Co., 1810 Frick Bldg., and 6411 Darlington Rd., Pittsburgh, Pa.

SPERZEL, Henry J. (*M* 1919; *A* 1918), Kewanee Boiler Co., 708-10 Builders Exchange, Minneapolis, Minn.

SPIELMANN, Gordon P. (*J* 1923), Vice-Pres. (for mail), Harrison-Spielmann Co., 480 Milwaukee Ave., Chicago, and 515 N. Prospect Ave., Park Ridge, Ill.

SPITZLEY, R. L. (*M* 1920), Pres. (for mail), R. L. Spitzley Htg. Co., 1200 W. Fort St., Detroit, and 1050 Yorkshire Rd., Grosse Pointe, Mich.

SPOONER, Harold R. (*M* 1921), Schaeffler-Spooner Htg. Corp., 92-32 Union Hall St., Jamaica, L. I., N. Y.

SPRAGUE, Frank H. (*M* 1923), Sarco Co., Engineers Bldg., Chicago, Ill.

SPROULL, Howard E. (*M* 1920), Dist. Mgr. (for mail), American Blower Corp., 905 Sycamore St., Cincinnati, and 3588 Raymar Dr., Hyde Park, Cincinnati, Ohio.

SPURGEON, Joseph H. (*M* 1924), Sales Engr. (for mail), 5203 General Motors Bldg., and 17215 Lilac Ave., Detroit, Mich.

STACEY, Alfred E., Jr.* (*M* 1914), Wootton Rd., Essex Fells, N. J.

STACK, Murle F. (*A* 1925), 116 N. Fifth St., Reading, Pa.

STACKHOUSE, Ray M. (*M* 1919; *A* 1908), Br. Mgr. (for mail), American Radiator Co., 820 S. Michigan Ave., and 73 E. Elm St., Chicago, Ill.

STAMMER, Edward L. (*M* 1919), Board of Education, 506-911 Locust St., St. Louis, Mo.

STANDISH, Myles (*M* 1929), Sales Engr. (for mail), Washburn-Garfield Co., and 36 Chestnut St., Worcester, Mass.

STANFORD, Leland E. (*M* 1921), 445 Hudson Rd., R. D. 3, Kent, Ohio.

STANGER, Ralph B. (*M* 1920), Mgr. (for mail), Robinson & Stanger, 1007 Empire Bldg., 728 East End Ave., Pittsburgh, Pa.

STANGLAND, B. F. (*Charter Member*), (2nd Vice-Pres., 1908; Board of Governors, 1905-1906-1909; Board of Mgrs., 1895-1899; Council, 1896-1897), Morton, N. Y.

STANNARD, James M. (*M* 1906), (Council, 1914-1917; Board of Governors, 1913), Stannard Power Equipment Co., 925-8 Monadnock Block, Chicago, Ill.

STANTON, Gerard W. (*M* 1928), Pres. (for mail), Almirall & Co., Inc., 53 Park Pl., New York, N. Y., and 231 Washington Pl., Hasbrouck Heights, N. J.

STAPLES, William H. (*A* 1924), (for mail), Gillis & Geoghegan, 537 W. Broadway, and 605 West 141st St., New York, N. Y.

STARK, W. Elliott* (*M* 1926), Research Engr., Bryant Heater & Mfg. Co., 17825 St. Clair Ave., Cleveland, and (for mail), 1875 Rosemont Rd., East Cleveland, Ohio.

STAUD, Clement J. (*A* 1929), Mgr., Htg. Dept., Harris Pump & Supply Co., 320 Second Ave., Pittsburgh, and (for mail), R. F. D. No. 4, Box 460-A, Millvale, Pa.

STEARNS, Walter I. (*A* 1926), Owner, W. I. Stearns Co., 560 North 16th St., Philadelphia, Pa.

STECKHAN, Louis (*M* 1928; *A* 1928; *J* 1926), Estimator, Crane Co. (for mail), 30 South 16th St., and 3014 Indiana Ave., St. Louis, Mo.

STEDMAN, Charles N. (*M* 1921), C. N. Stedman Co., 610 Wrigley Bldg., Chicago, Ill.

STEELE, Maurice G. (*M* 1929), The Rome Radiation Co., Rome, N. Y.

STEEN, Joseph M. (*M* 1929), Pres. (for mail), Iron City Htg. Co., 843 Jacksonia St., and 906 Quaill Ave., Bellevue, P. O., Pittsburgh, Pa.

STEIM, Charles J., Jr. (*M* 1923), Br. Mgr. (for mail), C. A. Dunham Co., 91 State St., and 949 Western Ave., Albany, N. Y.

STEINHORST, Theodore F. (*M* 1919), Engr. and Treas., Emil Steinhorst & Sons, Inc., 612-616 South St., and (for mail), 1664 Brinckerhoff Ave., Utica, N. Y.

STEINKE, George B. (*M* 1924), Pres. (for mail), George B. & B. H. Steinke Co., Inc., 103 Park Ave., New York, N. Y., and 375 North 13th St., Newark, N. J.

STEINMULLER, John M. (*M* 1925), Mech. Engr. (for mail), Thompson-Starrett Co., Inc., 245 Hunterspoint Ave., Long Island City, and Hawthorne, N. Y.

STEPHEN, Harold M. (*A* 1926), James E. Degan Co., 2130 Franklin St., Detroit, Mich.

STERN, H. Richard (*M* 1923), Owner (for mail), Johnson & Morris, 538 West 23rd St., and 225 West 86th St., New York, N. Y.

STETSON, Lawrence R. (*M* 1913), 303 Congress St., Boston, Mass.

STEVENS, F. H. (*A* 1924), Sales Engr., Pacific Steel Boiler Corp., and (for mail), 140 Winthrop St., Albany, N. Y.

STEVENS, Harry L. (*A* 1927; *J* 1924), Member of Firm, M. W. Stevens, 108 W. Sherman St., Hutchinson, Kans.

STEVENSON, Merle E. (*J* 1929), Repr., Stevenson Htg. Co., 1615 E. Main St., and (for mail), 51 South 16th St., Richmond, Ind.

STEVENSON, W. W. (*M* 1928), Steam Htg. Engr. (for mail), Allegheny County Steam Htg. Co., 435 Sixth Ave., and 1125 Lancaster Ave., Pittsburgh, Pa.

STEWART, C. W. (*M* 1919; *A* 1918), 21 Yates Ave., Waterbury, Conn.

STILES, Harry Leroy (*M* 1928), Mech. Engr., Edison Elec. Appliance Co., 5600 W. Tayler St., Chicago, Ill.

STILL, F. R.* (*M* 1904), (*Presidential Member*), (Pres., 1918; 2nd Vice-Pres., 1917; Council, 1916-1919), Vice-Pres. and Mgr. of Export (for mail), American Blower Corp., 30 Church St., and 1 East End Ave., New York, N. Y.

STITT, Eugene W. (*M* 1917), Sales Engr., National Radiator Corp., 1508 Arrott Bldg., Fourth Ave. and Wood St., Pittsburgh, and (for mail), 1535 Park Blvd., Dormont, Pittsburgh, Pa.

STITT, Howard B. (*A* 1922), Sales Engr. (for mail), National Radiator Corp., 431 W. Georgia St., and 5355 Broadway, Indianapolis, Ind.

STOCK, Edward L. (*A* 1918), Pres. (for mail), Edward L. Stock, Inc., 1117–15th St. N. W., and Bradley Hills, Bethesda, Md.

STOCKENBERG, Ruben (*M* 1922), Johnson Service Co., 1355 W. Washington Blvd., Chicago, Ill.

STOCKWELL, William R. (*M* 1903; *J* 1901), Weil-McLain Co., Michigan City, Ind.

STOKES, Ralph E. (*M* 1920), Ilg Elec. Vtg. Co., 1024 Bessemer Bldg., Pittsburgh, Pa.

STONE, Eugene R. (*M* 1913), 171 Harrison Ave., Boston, Mass.

STONE, George F. (*M* 1918), 4520 N. Carlisle St., Philadelphia, Pa.

STRACHAN, John S. (*M* 1928), Pres. (for mail), Strachan-Harrison, Inc., 243 State St., and 121 Furman St., Schenectady, N. Y.

STRANDWITZ, William J. (*M* 1919), Pres. (for mail), Strandwitz & Scott, Inc., 537 S. Second St., Camden, and 325 Hawthorne Ave., Haddonfield, N. J.

STRICKLAND, Albert W. (*A* 1929), Owner, Strickland Plbg. Htg. & Elec. Co., Big Timber, Mont.

STROCK, Clifford (*A* 1929), Associate Editor (for mail), *Heating and Ventilating* 521 Fifth Ave., and 500 Broadway, New York, N. Y.

STRONG, Edward A., Jr. (*A* 1928), 309 N. Alabama St., Indianapolis, Ind.

STRONG, Ralph C. (*M* 1919), 4515 Larchwood Ave., Philadelphia, Pa.

STROUSE, Sidney B. (*M* 1921), Dist. Mgr. (for mail), Warren Webster & Co., 429 Guarantee Trust Bldg., and 22 S. Illinois Ave., Atlantic City, N. J.

STURGES, Heyward A. (*A* 1928; *J* 1926), 90 N. W. O'Conner, St. Albans, Vt.

SUITS, George A. (*M* 1923), Service Engr., 26 Stanley Ave., Medford, Mass.

SULLIVAN, Daniel A. (*M* 1923), Engr. and Estimator, Callahan Engrg. Co., Inc., 20 Grove St., White Plains, and (for mail), 3178 Rochambeau Ave., New York, N. Y.

SUTCLIFFE, Arthur G. (*M* 1922; *A* 1918), 4146 N. St. Louis Ave., Chicago, Ill.

SUTTERLEY, W. W. (*M* 1919), 503 North 52nd St., Philadelphia, Pa.

SWAIN, Wilbur A. (*A* 1926), Jenkins Bros., 80 White St., New York, N. Y.

SWAN, Ernest H. (*M* 1929), Htg. and Vtg. Engr. (for mail), W. A. Swan & Sons, 122 Unley Rd., Unley, and 25 Austral Ter., Malvern, South Australia.

SWAN, Thomas J. (*A* 1927; *J* 1925), 23 Athelwold St., Dorchester, Mass.

SWANEY, Carroll R. (*M* 1929; *J* 1921), Gilbert Howe Gleason, 25 Huntington Ave., Boston, Mass.

SWARTWOUT, J. D.* (*M* 1917), Secy-Treas., J. D. Swartwout Co., 613 Millard St., and (for mail), 349 S. Weadock Ave., Saginaw, Mich.

SWEENEY, Sylvester H. (*M* 1915), (for mail), 306 East 39th St., New York, and 1916 Loring Pl., Bronx, N. Y.

SWIFT, Clement K. (*A* 1928), MacAndrews & Forbes Co., Third St. and Jefferson Ave., Camden, N. J.

SZEKELY, Ernest (*M* 1920), Chief Engr. (for mail), Bayley Blower Co., 732 Greenbush St., and 3104 Kilbourn Ave., Milwaukee, Wis.

T

TABBINER, Harold (*A* 1929), Salesman (for mail), Crane, Ltd., 306 Front St. W., and 24 Winona Dr., Toronto, Can.

TAGGART, Ralph C. (*M* 1912), 14 Lyon Ave., Menands, Albany, N. Y.

TALIAFERRO, Robert R. (*M* 1919), York Htg. & Vtg. Corp., 16th and Sansom Sts., Philadelphia, Pa.

TALLMADGE, Webster (*M* 1924), Pres., Webster Tallmadge & Co., Inc., 50 Church St., New York, N. Y.

TAVERNA, Frederick F. (*M* 1928; *A* 1927; *J* 1924), Engr., Raisler Htg. Co., 129 Amsterdam Ave., N. Y., and (for mail), 406–12th St., Union City, N. J.

TAYLOR, John H. (*A* 1928), Pres. (for mail), Hutchison Regulator Sales Corp., 4306–36th St., Long Island City, and 9344–215th Pl., Queens Village, L. I., N. Y.

TEAGUE, William Wallace* (*M* 1929), Research Engr. (for mail), Research Lab., A. S. H. V. E., 4800 Forbes St., and 244 Spahr St., Pittsburgh, Pa.

TEASDALE, Lawrence Aldrich (*M* 1926), Engr., Hollis French & Allen Hubbard, 210 South St., Boston, Mass. (for mail), 20 Ashmun St., and 199 Nicoll St., New Haven, Conn.

TEMPLIN, Charles L. (*M* 1921), Dist. Mgr. (for mail), York Htg. & Vtg. Corp., 810 Bona Allen Bldg., and 764 Greenwood Ave. N. E., Atlanta, Ga.

TENNANT, Ernest M. (*A* 1927), Br. Mgr. (for mail), C. A. Dunham Co., 312 Securities Bldg., and 1624 Boren Ave., Seattle, Wash.

TENNANT, Raymond John Jefferson (*A* 1929), 435 Sixth Ave., Pittsburgh, Pa.

TERRELL, Herbert A. (*M* 1915), Hampton Hall, Cranford, N. J.

THAIN, Arthur Edgar (*A* 1926), 2 E. Biddle St., Baltimore, Md.

THATCHER, George S. (*M* 1919), Pres. (for mail), Thatcher Htg. Co., 455 E. Exchange St., and 140 Morningside Dr., Akron, O.

THEORELL, Hugo (*Life Member*), Consulting Engr., Hugo Theorells Ingenieussbyra, Skoldungagatan 4, Stockholm, Sweden.

THINN, Christian A.* (*M* 1921), Chief Engr., C. A. Dunham Co., 230 E. Ohio St., Chicago, Ill.
THOMAS, Bernard A. (*A* 1927; *J* 1923), Sales Engr. (for mail), Crane Co., 705 W. Main St., and 3220 West 22nd St. N. W., Oklahoma City, Okla.
THOMAS, Herbert G. (*M* 1917), Sales Engr., Warren Webster & Co., 549 W. Washington St., Chicago, and (for mail), 2312 Ridge Ave., Evanston, Ill.
THOMAS, Melvern F. (*M* 1909), Consulting Engr., 229 College St., Toronto, Can.
THOMAS, Norman A. (*M* 1928), Pres. (for mail), Thomas Htg. Co., 1046 Herrick Ave., and 824 Monroe Ave., Racine, Wis.
THOMAS, R. H. (*M* 1920), Economy Pumping Machinery Co., 3431 West 48th Pl., Chicago, Ill.
THOMPSON, Charles (*A* 1927), 720–13th St., Sacramento, Calif.
THOMPSON, Nelson S.* (*M* 1917; *J* 1897), 1615 Hobart St. N. W., Washington, D. C.
THOMPSON, Richard C. (*M* 1927), Power Equipment Co., 250 Stuart St., Boston, Mass.
THOMPSON, William J. (*A* 1929), Imperial Iron Corp., Ltd., 250 St. Helens Ave., Toronto, Ont., Can.
THOMPSON, William P. (*M* 1915), 2146 E. Norris St., Philadelphia, Pa.
THOMSEN, William T. (*M* 1919), 3636 Fillmore St., St. Louis, Mo.
THOMSON, Thomas N. (*M* 1927), Consulting Engr., 37 Irwin Pl., Huntington, N. Y.
THORNTON, Roger T. (*M* 1919), Sales Engr. (for mail), Buffalo Forge Co., and 46 Burbank Ter., Buffalo, N. Y.
THRUSH, Homer A. (*M* 1918), H. A. Thrush & Co., 21-23 E. River St., Peru, Ind.
THUEM, Edward A. (*A* 1927; *J* 1922), Htg. and Vtg. Engr., Board of Education, Flatbush Ave. and Concord St., Brooklyn, N. Y., and (for mail), Harrington Park, N. J.
TIBBETS, John C. (*M* 1920), Htg. and Vtg. Engr., Engrg. Dept., Baltimore & Ohio R. R. Co., Room 1303, B. & O. Central Bldg., Baltimore, and (for mail), P. O. Box 106, Ellicott City, Md.
TILDEN, Elwyn E. (*M* 1924), Asst. Mgr., N. E. Dist. (for mail), Warren Webster & Co., 76 Summer St., Boston, and Holbrook, Mass.
TIMMERMAN, Manford Monroe (*M* 1925; *J* 1921), Supervisor of Works Engrg., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, and (for mail), 859 E. Hutchinson Ave., Swissvale, Pa.
TIMMIS, Pierce (*M* 1920), Service Equipment Engr. (for mail), United Engineers & Constructors, Inc., 112 N. Broad St., Philadelphia, and 202 Midland Ave., Wayne, Pa.
TIMMIS, W. Walter (*A* 1925), Consulting Engr., Timmis & Langgaard, 2nd National Bk. Bldg., Hempstead, and (for mail), Oak Lane, Glen Cove, N. Y.
TINKER, A. K. (*M* 1927), Special Repr., National Radiator Corp., McKinley Bldg., and (for mail), 338 Beard Ave., Buffalo, N. Y.
TINKER, William E. (*A* 1922), National Radiator Co., 121 N. Broad St., Philadelphia, Pa.
TISNOWER, William (*M* 1923), 131 Livingston St., Brooklyn, N. Y.
TITUS, Marvin Sinclair (*M* 1928), Htg. and Vtg. Engr., H. K. Ferguson Co., Hanna Bldg. Cleveland, O.
TJERSLAND, Alf (*M* 1916; *J* 1906), E. Sunde & Co., Christiania, Norway.
TOBIN, George J. (*M* 1905), 187 North Ave., Plainfield, N. J.
TOMLINSON, Malcolm C. W.* (*M* 1924), 130 W. Penn St., Germantown, Philadelphia, Pa.
TOOKER, Charles C. (*M* 1918), 116 North 27th St., Billings, Mont.
TRANE, Reuben N. (*M* 1915), Pres., The Trane Co., Htg. Equipment, and (for mail), 126 South 15th St., La Crosse, Wis.
TRUE, John E. (*J* 1929), Dist. Mgr. (for mail), York Htg. & Vtg. Corp., 622 Broadway, Cincinnati, and 2615 Sheridan Dr., Norwood, Ohio.
TRUITT, Joseph E. (*M* 1920; *A* 1911), Autovent Fan & Blower Co., 1805-27 N. Kostner Ave., Chicago, Ill.
TRUMBO, Silas M. (*A* 1926), Buffalo Forge Co., 562 W. Washington Blvd., Chicago, Ill.
TUCKER, Frank N. (*M* 1926), 13 Park Row, Room 1108, New York, N. Y.
TURNER, John W. (*M* 1928), Chief Engr. (for mail), Pacific Steel Boiler Corp., and 233 Stewart Ave., Waukegan, Ill.
TURNO, Walter G. W. (*M* 1917; *A* 1912), 71 Lafayette Ave., East Orange, N. J.
TUSCH, Walter (*M* 1917), 881 Sterling Pl., Brooklyn, N. Y.
TUTTLE, J. Frank (*M* 1913), Mgr. (for mail), Warren Webster & Co., 76 Summer St., Boston, and 5 Lewis Rd., Winchester, Mass.
TWIST, Charles F. (*M* 1921), Ashwell, Twist & Cook, 967 Thomas St., Seattle, Wash.
TYLER, Frank T. (*M* 1922), Asst. Sales Mgr. (for mail), Herman Nelson Corp., 1824 Third Ave., and 1615 Eighth Ave., Moline, Ill.
TYLER, Roy Dexter (*M* 1928), Sales Mgr. (for mail), Modine Mfg. Co., Rooms 1533-34, 101 Park Ave., New York, and 33 Elm Ave., Larchmont, N. Y.
TYSON, William Hope (*M* 1923), Mgr. of Engrg. (for mail), Goodyear Tyre & Rubber Co., Ltd., and "Kipewa," Codsall Rd., Wolverhampton, England.

U

UHL, Edwin J. (*M* 1925), Sales Engr. (for mail), 132 S. Tenth St., and 4830 Pleasant Ave. S., Minneapolis, Minn.
UHL, Willard F. (*M* 1918), 4716 Lyndale Ave., Minneapolis, Minn.
UHLHORN, W. J. (*M* 1920), 733 S. Highland Ave., Oak Park, Ill.
ULLMAN, Herbert G. (*A* 1928), American Radiator Co., 675 Bronx River Rd., Yonkers, N. Y.
ULRICH, Kay Flemming (*J* 1926), Smedegade, Slagelse, Denmark.
UNDERHILL, William W. (*M* 1913), Treas. (for mail), Stone-Underhill Htg. & Vtg. Co., 171 Harrison Ave., Boston, and 15 Kenwood St., Brookline, Mass.

V

VALIQUET, Harry Howell (*A* 1926), Sales Engr., Allen & Billmyre Co., Inc., 1240 Builders Bldg., 223 N. La Salle St., and (for mail), 6436 N. Albany, Chicago, Ill.
VAN ALEN, Walter T. (*M* 1924), 1300 Darlington Rd., R. D. 1, Beaver Falls, Pa.
VAN ALSTYNE, Richmond F. (*A* 1928), Br. Mgr. (for mail), Johnson Service Co., 312 E. Ohio St., and 323 East 49th St., Indianapolis, Ind.
VANCE, Louis G. (*M* 1919), Mgr., Baltimore Office (for mail), The Ric-wiL Co., 517 Garrett Bldg., and 3601 Garrison Blvd., Baltimore, Md.
VAN NORDEN, Ernest M. (*M* 1923), Civil Engr. (for mail), The New York Edison Co., 130 East 15th St., New York, and 120 Stratford Ave., Garden City, L. I., N. Y.
VAN SICKLE, William B. (*M* 1915), Pres. (for mail), The W. B. Van Sickle Co., 723 Frankfort Ave., Cleveland, and 1530 Grace Ave., Lakewood, Ohio.
VAN ZANDT, John H. (*M* 1914), 408 Dallas National Bk. Bldg., Dallas, Tex.
VAUX, Noble (*A* 1923), 11 Holmelands Park S., Sunderland, England.
VER HALEN, Edward T. (*A* 1925), 610 Milwaukee St., Milwaukee, Wis.
VERMERE, Earl J. (*M* 1929), Chief Engr., Htg. Div. (for mail), Air-Way Electrical Appliance Corp., 2101 Auburn Ave., and 2532 Cherry St., Toledo, Ohio.
VERNER, William F. (*M* 1913), Verner, Wilhelm & Shreve, 760 Book Bldg., Detroit, Mich.

VERNON, J. Rexford (*M* 1928; *A* 1926), Sales Engr., Johnson Service Co., 1355 Washington Blvd., Chicago, and (for mail), 1020 Austin St., Evanston, Ill.
VIVARTTAS, E. Arnold (*M* 1910), Mech. Engr., Jardin, Hill & Murdock, Architects, 347 Madison Ave., New York, and (for mail), 10 Midwood St., Brooklyn, N. Y.
VOGEL, Andrew (*M* 1926), Plant Engr. (for mail), General Elec. Co., and 611 Lenox Rd., Schenectady, N. Y.
VOGELBACH, Oscar (*M* 1923), 195 Devon St., Kearny, N. J.
VOGT, J. H. (*A* 1925), 124 East 28th St., New York, N. Y.
VOIGT, Charles O. (*M* 1921), Sterns Roger Mfg. Co., 1720 California St., Denver, Colo.
VOLK, Joseph H. (*M* 1923), Pres. and Treas. (for mail), Thos. E. Hoye Htg. Co., 1910 St. Paul Ave., and 1385–37th Ave., Milwaukee, Wis.
VOORHEES, Guy A. (*M* 1922), Engr., Century Htg. Service, 633 S. Delaware St., and (for mail), 3451 Broadway, Indianapolis, Ind.

W

WADE, Norman S. (*M* 1926), Asst. Supt., Steam Htg. Service Dept., Edison Elec. Illuminating Co. of Boston, 39 Boylston St., Boston, Mass.
WAECHTER, Herman Paul (*J* 1927), Architects Repr., Celotex Co., 101 Park Ave., New York, and (for mail), 89 Sherman Ave., Tompkinsville, N. Y.
WAGNER, A. M. (*A* 1921), Mgr., American Radiator Co., 692 Prior Ave., St. Paul, Minn.
WALKER, Alex. (*A* 1925), Br. Mgr. (for mail), C. A. Dunham Co., Ltd., 1307 Fifth St. W., and 603–13th Ave. W., Calgary, Alberta, Can.
WALKER, George E. (*M* 1929), Sales Engr., Weil Pump Co., 215 W. Superior St., and (for mail), 1430 Lunt Ave., Chicago, Ill.
WALKER, George F. (*J* 1925), Sales Engr. (for mail), Spencer Heater Co., 831 Connell Bldg., Scranton, and Waverly Rd., Clarks Green, Pa.
WALKER, James B. (*M* 1919), Secy. (for mail), Htg. & Piping Contractors, 715 Magee Bldg., and Iroquois Apts., Oakland, Pittsburgh, Pa.
WALKER, James H. (*M* 1916), Supt. of Central Htg. (for mail), Detroit Edison Co., 2000 Second Ave., and 1520 Virginia Park, Detroit, Mich.
WALKER, William K. (*J* 1924), Sales Engr., York Htg. & Vtg. Corp., 149 Broadway, New York, N. Y.
WALLACE, George J. (*M* 1923), Engr. and Contractor, 1006 First Ave., New York, and (for mail), 27-36 Ericsson St., E. Elmhurst, N. Y.
WALLACE, William M., Jr. (*M* 1929), Vtg. Engr., Charles Hartmann Co., 985 Dean St., Brooklyn, and (for mail), 8908–196th St., Hollis, L. I., N. Y.
WALSH, Arthur F. (*A* 1923), Htg. and Vtg. Contractor, 7445 Exchange Ave., Chicago, Ill.
WALSH, James A. (*J* 1929), Br. Mgr. (for mail), Rome Brass Radiator Corp., 400 Widener Bldg., Philadelphia, Pa.
WALSH, John Henry (*J* 1927), Engr., 10 Fairview Ave., New York, N. Y.
WALSH, Joseph F. (*M* 1928), 1163 Ocean Parkway, Brooklyn, N. Y.
WALSH, Malcolm (*M* 1924), Vice-Pres. (for mail), Walsh & Wertheim, 504 W. Broadway, New York, and 91 Penbroke Ave., West New Brighton, S. I., N. Y.
WALTERS, Arthur L. (*M* 1926; *A* 1925; *J* 1924), Chief Engr., Langenberg Mfg. Co., 4519 N. Euclid Ave., St. Louis, Mo.
WALTERS, Victor (*J* 1924), Htg. and Vtg. Engr., 7048 St. Lawrence Ave., Chicago, Ill.
WALTERS, William T. (*M* 1917), 8053 Ingleside Ave., Apt. 2, Chicago, Ill.
WALTERTHUM, John J. (*A* 1922), Htg. and Vtg. Contractor, 173 East 62nd St., New York, N. Y., and (for mail), 834 Grant St., Jersey City, N. J.
WALTHER, Harry J. (*M* 1919), Salesman (for mail), The H. B. Smith Co., 2209 Chestnut St., and 1115 Duncannon Ave., Philadelphia, Pa.
WALTHER, Vernon H. (*M* 1928; *J* 1927), Mech. Engr. (for mail), Wendt & Crone Co., 2124 Southport Ave., and 6821 Osceola Ave., Edison Park, Chicago, Ill.
WALTON, Hiram Lessiter* (*M* 1916), Member of Firm (for mail), Smith, Hinchman & Grylls, 800 Marquette Bldg., and 244 Hildale Ave., Detroit Mich.
WANDLESS, Franklin W. (*M* 1925), Chief Engr. (for mail), Haynes Selling Co., Inc., 2013 Sansom St., Philadelphia, and Berwyn, Pa.
WARD, George C. (*M* 1925), 86–87th St., Brooklyn, N. Y.
WARD, Lawrence T. (*A* 1928), Sales Div. (for mail), David Lupton Sons Co., Allegheny Ave. and Tulip St., and 1457 Lardner St., Philadelphia, Pa.
WARD, Oscar G. (*M* 1919), Mgr. (for mail), Johnson Service Co., 1230 California St., and 1009 Grant St., Denver, Colo.
WARREN, Clarence N. (*M* 1919), 419 East 48th St., Indianapolis, Ind.
WASH, William Percy (*M* 1923), Pres. (for mail), Colonial Supply Co., 1511 S. Jefferson St., Roanoke, and 303 Stanley Ave., South Roanoke, Va.
WASHINGTON, Laurence W. (*M* 1929), 2301 Knox Ave., Chicago, Ill.
WATERS, George G. (*A* 1926), Dist. Mgr. (for mail), American Blower Corp., 801 First National Bk. Bldg., Pittsburgh, and 3508 Meadowcroft Ave., Mt. Lebanon, Pa.
WATSON, John H. (*M* 1925), Engr., Drying Systems, Inc., 1800 Foster Ave., and (for mail), 2045 Farragut Ave., Chicago, Ill.
WATSON, M. Barry (*M* 1928), Consulting Engr., Angus and Watson, 25 Bloor St. W., Toronto, 5, Canada.
WATTERS, Peter J. (*M* 1921), 52 Ann St., Port Richmond, S. I., N. Y.
WEAGER, T. A. (*M* 1920), Dist. Mgr. (for mail), Buffalo Forge Co., Rockefeller Bldg., and 3124 Berkshire Rd., Cleveland, Ohio.
WEBB, John S. (*M* 1920), Mgr., New England Br. (for mail), The Herman Nelson Corp., 517 Statler Bldg., Boston, and 16 Brookline St., Needham, Mass.
WEBB, John William (*M* 1926), Managing Director, Webb Dust Removing & Drying Co., Ltd., Tiviot Dale Chambers, and (for mail), 6 Meadows Rd., Heaton Chapel, Stockport, England.
WEBER, Erwin L. (*M* 1921), Consulting Engr., 723-4 Seaboard Bldg., Seattle, Wash.
WEBER, G. A. (*M* 1922), 207 Taylor St., Pittsburgh, Pa.
WEBSTER, E. Kessler (*M* 1915), Secy. and Asst. Gen. Mgr., Warren Webster & Co., 17th and Federal Sts., Camden, N. J.
WEBSTER, Warren (*M* 1906; *A* 1899), Pres., Warren Webster & Co., 17th and Federal Sts., Camden, N. J.
WEBSTER, Warren, Jr. (*J* 1927), Asst. Secy., Warren Webster & Co., 17th and Federal Sts., Camden, N. J.
WEGMANN, Albert (*M* 1918), Owner, A. Wegmann Co., 2813 W. Fletcher St., and (for mail), 6206 North 17th St., Philadelphia, Pa.
WEIDER, Frederick J. (*M* 1919), Vice-Pres. and Treas. (for mail), Barr & Creelman Co., 74 Exchange St., and 40 Kenwood Ave., Rochester, N. Y.
WEIL, Martin (*A* 1925), Secy., Weil-McLain Co., 641 W. Lake St., Chicago, Ill.
WEIL, Maurice I. (*A* 1928), Pres. (for mail), Chicago Pump Co., 2336 Wolfram St., and 1409 Elmdale Ave., Chicago, Ill.
WEIMER, Fred G. (*A* 1919), 1308 Stowell Ave., Milwaukee, Wis.
WEINSHANK, H. T. (*J* 1924), Sales Engr., Abbot Vtg. Co., Inc., 5426 S. La Salle St., Chicago, Ill.

WEINSHANK, Theodore (*M* 1906), (Board of Governors, 1913), 2323 Kedzie Blvd., Chicago, Ill.

WEISS, Arthur Paul (*M* 1928), Asst. Treas., Burnham Boiler Corp., Irvington, and (for mail), 134 Farrington Ave., North Tarrytown, N. Y.

WEISS, Carl A. (*A* 1924), Supt., Kornbrodt Kornice Ko., 1811 Troost Ave., Kansas City, Mo.

WEITZEL, Robert D. (*J* 1929), Htg. Contractor, 2312 Penn St., Harrisburg, Pa.

WEIXEL, Albert L. (*M* 1928), Consulting Engr., 1020 Builders Bldg., 228 N. La Salle St., Chicago, Ill.

WELAMB, Victor N. (*M* 1918), V. N. Welamb Co., 105 N. Watts St., Philadelphia, Pa.

WELCH, Louis A., Jr. (*A* 1929), Owner, Welch Bros., 1667 Broadway, Schenectady, N. Y.

WELLS, Harry N. (*A* 1928; *J* 1927), 44 Fuller Pl., Irvington, N. J.

WELSH, Harry S. (*M* 1906), Pres., Boiler & Radiator Corp., 999 E. Main St., Rochester, N. Y.

WENDT, Edgar F. (*M* 1918), Buffalo Forge Co., 490 Broadway, Buffalo, N. Y.

WEST, Baird F. (*J* 1928), Asst. on Market Surveys (for mail), Engineering News Record, 475 Tenth Ave., and 417 Riverside Dr., N. Y.

WEST, Perry* (*M* 1911), (Council, 1920-1925; Treas., 1924-1925), Consulting Htg., Vtg., Plbg. and Elec. Engr. (for mail), 13 Central Ave., and 445 Ridge St., Newark, N. J.

WHEELER, Charles W. (*M* 1916), Br. Mgr. (for mail), C. A. Dunham Co., 3002 Grant Bldg., Pittsburgh, and Allison Park, Pa.

WHEELER, Otto J. (*M* 1923), Mgr. and Secy., 548-558 W. Broad St., and (for mail), 504 Linwood Ave., Columbus, Ohio.

WHELAN, William F. (*J* 1928), 222 W. Lancaster Ave., Ardmore, Pa.

WHELAN, William J. (*M* 1923), Estimator and Purchaser (for mail), Harrigan & Reid Co., 1365 Baker St., and 3790 Seminole Ave., Detroit, Mich.

WHELLER, Harry S. (*M* 1916), Vice-Pres., L. J. Wing Mfg. Co., 154 West 14th St., New York, N. Y., and (for mail), 725 Union Ave., Elizabeth, N. J.

WHITAKER, Ernest C. (*M* 1925), 35 Sherborn St., Arlington, Mass.

WHITBY, Stephen S. (*A* 1922), Treas., Culbert-Whitby Co., Inc., 2019 Rittenhouse St., and (for mail), 127 E. Upsal St., Germantown, Philadelphia, Pa.

WHITE, C. Ferber (*M* 1929), Philadelphia Mgr., Modine Mfg. Co., 3110 Market St., Philadelphia, and (for mail), Roslyn, Pa.

WHITE, E. A. (*M* 1921), Engrg. Dept., Crane Co., 30 South 16th St., and (for mail), 5244 Nottingham, St. Louis, Mo.

WHITE, Elwood S. (*M* 1921), Pres., Taco Heaters, Inc., Room 1224, 342 Madison Ave., New York, N. Y.

WHITELAW, H. Leigh (*M* 1916), Vice-Pres. and Gen. Mgr., American Gas Products Corp., 376 Lafayette St., New York, N. Y.

WHITELEY, James (*M* 1919), Consulting Engr., 3000 Grand River Ave., Detroit, Mich.

WHITNAH, C. S. (*M* 1927), 6 Lakeside Court, Duluth, Minn.

WHITTEMORE, Edward H.* (*M* 1920), Engr., Stone & Webster, Inc., 49 Federal St., Boston, Mass.

WHITTEN, Herbert W. (*M* 1909; *A* 1908), Htg. and Mech. Engr., Chamberlin Metal Weatherstrip Co., 134 Congress St., Boston, Mass.

WHITTEN, Horace E. (*M* 1924), Pres. and Treas. (for mail), H. E. Whitten Co., 9 Federal Court, Boston, and 56 Highland Rd., Somerville, Mass.

WHITTINGTON, W. Penrose (*M* 1928), Pres. (for mail), W. P. Whittington, Inc., 404 Lumber Insurance Bldg., and 79th and White River, Indianapolis, Ind.

WHY, H. Berkeley (*M* 1919), Engr., Galligan Bros., 716 North 51st St., Philadelphia, Pa.

WIDDICOMBE, R. A. (*M* 1903), 1120 Lake Shore Dr., Chicago, Ill.

WIEGNER, Henry B. (*M* 1919), Office Mgr., Johnson Service Co., 31 Waltham St., Boston, and (for mail), 143 Standish Rd., Watertown, Mass.

WIERSIG, Robert H. (*A* 1927), Pres. (for mail), Rud Wiersig, Inc., 2311 N. California Ave., and 2445 Thorndale Ave., Chicago, Ill.

WIGGS, G. Lorne (*J* 1924), Consulting Engr. (for mail), 1410 Stanley St., Montreal, and 4643 Sherbrooke St., Westmount, Quebec, Canada.

WIGLE, Bruce M. (*A* 1926), Owner, Bruce Wigle Plbg. and Htg. Co., 9117 Hamilton Ave., Detroit, Mich.

WILD, Walter H. (*M* 1927; *A* 1921), (for mail), Walter H. Wild, Inc., 1014 Land Title Bldg., Philadelphia, and 122 Cynwyd Rd., Bala, Cynwyd, Pa.

WILDE, Ray S. M.* (*M* 1916), Consulting Engr. (for mail), 1216 Michigan Theater Bldg., Detroit, and 194 Connecticut Ave., Highland Park, Mich.

WILDER, Edward L. (*M* 1915), Mgr. Industrial Sales Dept. (for mail), Rochester Gas & Elec. Corp., 89 East Ave., and 16 Ericsson St., Rochester, N. Y.

WILEY, Charles S. (*M* 1921), Htg. and Vtg. Engr., Eastman Kodak Co., Kodak Park, Rochester, N. Y.

WILEY, Edgar C. (*M* 1909), Consulting Engr., Wiley & Wilson, Lynchburg, Va.

WILLARD, Arthur C.* (*M* 1914), (*Presidential Member*), (Pres., 1928; 1st Vice-Pres., 1927; 2nd Vice-Pres., 1926; Council, 1925-1929), Prof. Htg. and Vtg., and Head of Dept. of Mech. Engrg. (for mail), University of Illinois, and 1208 W. California St., Urbana, Ill.

WILLIAMS, Allen W. (*A* 1915), Managing Dir., National Warm Air Htg. Asosciation, 174 E. Long St., Columbus, Ohio.

WILLIAMS, Grover M. (*M* 1928), Secy-Treas., Bevington-Williams, Inc., 1134-39 Indiana Pythian Bldg., Indianapolis, Ind.

WILLIAMS, Jesse M. (*A* 1925), Pres., Williams Radiator Co., 1869 W. Cordova St., Los Angeles, Calif.

WILLIAMS, J. McFarland, Jr. (*A* 1928; *J* 1927), Sales Engr., 2401 Garrison Ave., Baltimore, Md.

WILLIAMS, J. Walter (*M* 1915), Pres. and Treas., Forest City Plbg. Co., 332 E. State St., Ithaca, N. Y.

WILLIAMS, O. L. (*A* 1925), 509 Mellett Bldg., Canton, Ohio.

WILLIAMS, Robert Eubank (*M* 1926), Consulting Engr., 308 Home Insurance Bldg., Little Rock, Ark.

WILLIAMSON, A. H. (*A* 1915), Sales Mgr., American Radiator Co. of Michigan, 1344 Broadway, Detroit, Mich.

WILLIAMSON, Fred W. (*M* 1914), Consulting Engr., 1418 East 34th St., Brooklyn, N. Y.

WILLIS, F. H. (*M* 1921), Consulting Engr. (for mail), 740 Gas & Elec. Bldg., and 1110 Jackson St., Denver, Colo.

WILLIS, Roy C. (*M* 1927), Vice-Pres. and Secy. (for mail), Vapor Engrg. Co., 489 Fifth Ave., and 145 Audubon Ave., New York, N. Y.

WILLIS, William Jasper (*M* 1927), c/o Mrs. J. A. Ruble, 351 Kirk Pl., San Antonio, Tex.

WILMOT, Charles S. (*M* 1919), Supervising Engr., United Engrs. & Constructors, Inc., 112 N. Broad St., Philadelphia, and (for mail), 227 Fifth Ave., Phoenixville, Pa.

WILSON, Benjamin W. (*M* 1922), Htg. and Vtg. Engr. (for mail), The Ballinger Co., S. E. Cor. 12th and Chestnut Sts., Philadelphia, and 5935 Windsor Ave., West Philadelphia, Pa.

WILSON, Charles H. (*M* 1920), Htg. and Vtg. Engr., Fuller and Warren Co., 1403 Park Blvd., Troy, N. Y.

WILSON, Ernest J. F. (*M* 1923), Partner (for mail), Wiley & Wilson, Consulting Engrs., 801 Main St., and Box 150, Route 4, Lynchburg, Va.

WILSON, F. A. (*M* 1910), 209-45–110th Ave., Bellaire, L. I., N. Y.

WILSON, George T. (*M* 1925), Tyre Ave., Islington, Ont., Canada.

WILSON, Harry A. (*Charter Member; Life Member*), P. O. Box 155, Washington, R. I.

WILSON, Howard M. (*A* 1925), Standard Heater Co., 136 Federal St., Boston, Mass.

WILSON, J. J. (*Charter Member; Life Member*), Consulting Engr. (for mail), 5514 Paschall Ave., and Hayes Home, Belmont Ave., Philadelphia, Pa.

WILSON, William H. (*A* 1923), Mgr. Milwaukee Office (for mail), Johnson Service Co., 149-159 E. Michigan St., and 431 Olive St., Milwaukee, Wis.

WILSON, William Seath (*A* 1924), Field Engr. (for mail), Algoma Steel Corp., and 210 McGregor Ave., Sault Ste. Marie, Canada.

WINANS, Glen D. (*M* 1929), Engr. of Steam Distribution, The Detroit Edison Co., 2000 Second Ave., and (for mail), 16183 Wisconsin, Detroit, Mich.

WINTERBOTTOM, John W. (*M* 1915), Pres. (for mail), Winterbottom Supply Co., Commercial and Miles Sts., and 432 Denver St., Waterloo, Ia.

WINTERER, Alfonso V. (*A* 1929), Secy. Reuben L. Anderson, Inc. & Asbestos Products Corp., 1834 St. Clair St., and (for mail), 1580 Race St., St. Paul, Minn.

WINTERER, Frank C. (*M* 1920), Htg. Dept., Cochran Sargent Co., Third and Broadway, St. Paul, Minn.

WISE, Frank W. (*A* 1918), Mgr. (for mail), C. A. Dunham Co., 430 Terminal Tower Bldg., and 12505 Edgewater Dr., Cleveland, Ohio.

WISE, Mason W. (*M* 1923), Pres. (for mail), M. W. Wise Co., 214 Glenn Bldg., and 1656 Melrose Dr. S. W., Atlanta, Ga.

WITTLEDER, Edward A. (*J* 1926), Engr., Western Vtg. & Engrg. Co., 24 S. Clinton St., and (for mail), 3429 Medill Ave., Chicago, Ill.

WOLF, J. C. (*M* 1923), Engr., B. F. Sturtevant Co., Sturtevant, and (for mail), 1367 Stowell Ave., Milwaukee, Wis.

WOLFF, Oscar H. (*M* 1926), 6232 Oakland Ave., St. Louis, Mo.

WOLFF, Richard A. (*M* 1919; *J* 1915), Pres. (for mail), Wolff & Munier, Inc., 222 East 41st St., New York, and Woodmere, L. I., N. Y.

WOLFSFELD, Charles F. (*M* 1923), Vista Ave., Bayside, L. I., N. Y.

WOOD, James Sydney (*M* 1926), Estimator (for mail), The Bennett & Wright Co., Ltd., 72 Queen St. E., and 110 Balmoral Ave., Toronto, Canada.

WOODLING, Miner D. (*M* 1926), Owner and Manager (for mail), Miner D. Woodling Htg. & Vtg. Co., 811 Midland Bldg., and 1002 Greenway Ter., Kansas City, Mo.

WOODLOCK, William M. (*A* 1929), Sales Engr., York Htg. & Vtg. Corp., 149 Broadway, New York, N. Y., and (for mail), R. F. D. No. 1, Elizabeth, N. J.

WOOLEY, Thos. R. (*M* 1916), 3267 Tyler Ave., Detroit, Mich.

WOOLSTON, Alfred H. (*M* 1919), Member of Firm, Bowers Bros. & Co., 2015 Sansom St., Philadelphia, Pa.

WOOLSTON, C. E. (*M* 1924), Treas. (for mail), Smith Twin Tubular Boiler Co., Inc., 1111 Frankford Ave., and 1510 North 28th St., Philadelphia, Pa.

WORM, Amdi (*A* 1924), 2424 East 68th St., Kansas City, Mo.

WORSHAM, Herman (*M* 1925; *J* 1918), Gen. Sales Office (for mail), Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, and 36 S. Munn Ave., East Orange, N. J.

WORTHING, E. (*M* 1923), Bayley Mfg. Co., 732 Greenbush St., Milwaukee, Wis.

WRIGHT, Harris H. (*M* 1917), Mgr., C. A. Dunham Co., Pacific Steel Boiler Co., 615 City Bk. Bldg., Kansas City, Mo.

WRIGHT, Kenneth A. (*M* 1921), Mgr., Johnson Service Co., 1113 Race St., Cincinnati, Ohio.

WUNDERLICH, Milton S.* (*M* 1925), 1598 Laurel Ave., St. Paul, Minn.

WYLIE, Howard McW. (*M* 1925; *J* 1917), Vice-Pres., In Charge of Sales, Nash Engrg., Co. South Norwalk, Conn.

Y

YAGER, John J. (*M* 1921), 272 Carlton St., Buffalo, N. Y.

YAGLOU, Constantin P.* (*M* 1923), Instructor in Ventilation (for mail), Harvard School of Public Health, 55 Van Dyke St., and 1626 Commonwealth Ave., Boston, Mass.

YAMASAKI, Kanjiro (*A* 1923), Htg. Engr., Daiwa Kogyo Co., Ltd., First Mutual Bldg., Room 216, No. 5-3 Chome Denmacho, Kyobashi-ku, Tokyo, Japan.

YARDLEY, Ralph W. (*M* 1920), Asst. Architect, Board of Education, City of Chicago, Steuben Bldg., Cor. Randolph and Wells Sts., and (for mail), 817 N. Dearborn St., Chicago, Ill.

YATES, Walter (*M* 1902), Governing Dir. (for mail), Matthews & Yates, Ltd., Cyclone Works, and Parksend, Swinton, Manchester, England.

YOCKEL, Thomas J. (*A* 1929), 3190 Rochambeau Ave., New York, N. Y.

Z

ZACK, Hans J. (*M* 1928), Prop., Zack Co., 2311 Van Buren St., Chicago, Ill.

ZECK, Alex. (*Life Member*), Pres., Alex. Zeck & Son Co., 902 University Ave., Morgantown, W. Va.

ZELDITCH, Morris (*M* 1928), Mfrs. Agent, 212 Fitzsimons Bldg., and (for mail), 2301 Lutz Ave., Carrick, Pittsburgh, Pa.

ZIBOLD, Carl Edward (*M* 1929), Pres. and Chief Engr. (for mail), Zibold and Donohue Co., Inc., 331 Vanderbilt Ave., Brooklyn, and 78-55–80th St., Glendale, N. Y.

ZIEL, Herbert E. (*M* 1924), Htg. and Vtg. Engr. Architects and Engrs. (for mail), 1000 Marquette Bldg., Detroit, and 153 Robertson St., Mt. Clemens, Mich.

ZINGSHEIM, George Godfrey (*M* 1927), 4011 Pleasant Ave., Minneapolis, Minn.

ZOKELT, C. G. (*M* 1921), Consulting Engr. (for mail), 414 Central Bldg., and 2355–16th Ave. S., Seattle, Wash.

ZORB, Henry P. (*M* 1927), Htg. Engr. (for mail), 2620 Fourth Ave., and 2618 Fourth Ave., Detroit, Mich.

ZUEHLKE, Rudolph (*M* 1923), Zuehlke Htg. Co., 281 N. Main St., Wauwatosa, Wis.

ZUHLKE, William Ronald (*M* 1928), Engr., American Radiator Co., 40 West 40th St., New York, and (for mail), 530 McLean Ave., Yonkers, N. Y.

Summary of Membership

(Corrected to December 1, 1929)

UNITED STATES

Alabama	5	Missouri	100
Arkansas	2	Montana	5
California	25	Nebraska	1
Colorado	12	New Jersey	97
Connecticut	27	New York	395
Delaware	4	North Carolina	6
District of Columbia	9	Ohio	75
Florida	5	Oklahoma	6
Georgia	10	Oregon	1
Illinois	271	Pennsylvania	288
Indiana	46	Rhode Island	9
Iowa	8	Tennessee	6
Kansas	8	Texas	12
Kentucky	9	Utah	1
Maine	6	Vermont	4
Maryland	19	Virginia	14
Massachusetts	107	Washington	21
Michigan	115	West Virginia	7
Minnesota	55	Wisconsin	52
Mississippi	1		
			1844

FOREIGN COUNTRIES

Australia	3	Ireland	1
Belgium	1	Japan	6
Canada	69	New Zealand	1
China	6	Norway	1
Denmark	2	Russia	1
England	17	South America	1
France	3	Sweden	1
Germany	2	Switzerland	1
Holland	1		
			117

Total Membership 1961

SUMMARY OF MEMBERSHIP BY GRADES

Honorary Members	2
Presidential Members	19
Members	1411
Associate Members	402
Junior Members	126
Student Member	1
	1961

LIST OF MEMBERS

Arranged Geographically

UNITED STATES

ALABAMA

Birmingham—

Boisclair, H. C.
Festorazzi, A. O.
Gronberg, C. E.
Lichty, A. J.
Lichty, C. P.

ARKANSAS

Little Rock—

Williams, R. E.

Siloam Springs—

Jones, C. R.

CALIFORNIA

Berkeley—

Chapman, F. T.
Mead, W. R.

Beverly Hills—

Nelson, H. A.

Burlingame—

Douglass, T. C.

Glendale—

Dougherty, P. J.

Los Angeles—

Adrianse, P. R.
Arthur, H. W.
Bain, J. G.
Berg, A. H.
Bowles, P.
Ott, O. W.
Polderman, L. H.
Simonds, A. H.
Williams, J. M.

Oakland—

Cummings, G. J.

Pasadena—

Gifford, R. L.
Hoffman, G. D.

Sacramento—

Duncan, G. W., Jr.
Thompson, C.

San Diego—

Hemingway W. S.
Sadler, C. B.

San Francisco—

Haley, H. S.
Hunt, P. M.
Krueger, J. I.
Leland, W. E.

COLORADO

Colorado Springs—

Higgins, D. T.
Jardine, D. C.

Denver—

Adams, C. W.
Daly, J. H.
Deranleau, R. L.
Fielding, H. H.
Foley, W. J.
Herman, H. H.
Larimer, W. M.
Voigt, C. O.
Ward, O. G.
Willis, F. H.

CONNECTICUT

Bridgeport—

Callahan, M. J.
Clement, E. R.

Hartford—

Purcell, A. J.

New Britain—

Cadwell, W. H.
Fenner, E. M.

New Haven—

Catlin, B. J.
Hoyt, W. B.
Jenkins, H. E.
Lockwood, E. H.
Menzies, F. R.
Teasdale, L. A.

New London—

Forsberg, W.
Hopson, W. T.

Noroton Heights—

Ashley, E. E.

Riverside—

Jones, A. L.

Springdale—

Broderick, J. F.

South Norwalk—

Harvey, A. D.
Jennings, I. C.
Mead, E. A.
Wylie, H. M.

Stamford—

Davidson, R. A.

Waterbury—

Fenner, N. P.
Rech, P. D.
Simpson, W. K.
Stewart, C. W.

Winsted—

Griffin, P. C.
Hutton, W.

DELAWARE

Wilmington—

Gawthrop, F. H.
Kershaw, M. G.
Lownsbery, B. F.
Schoenijahn, R. P.

DISTRICT OF COLUMBIA

Washington—

Breitenbach, G. C.
Chapman, D. W.
Coward, H.
Febrey, E. J.
Gardner, S. F.
Goldstein, A. M.
Hood, O. P.
Mewshaw, J. P.
Thompson, N. S.

FLORIDA

Jacksonville—

Denson, W.
Gassler, J. H.
Johnson, R. H.

Miami—

Croft, T.

Tampa—

Smith, V. A.

GEORGIA

Atlanta—

Alger, R. W.
Baird, F. E.
Clare, F. W.
Kent, L. F.
Klein, E. W.
Templin, C. L.
Wise, M. W.

Columbus—

Dexter, M. D.
Hartpence, C. C.

Gainesville—

Jackson, J. W.

ILLINOIS

Arlington Heights—

Atkinson, R. E.

Berwyn—

Kitch, S. B.
Moran, F. E.

Bloomington—

MaGirl, W. J.
Nesmith, O. E.
Soper, H. A.

Chicago—

Abrahamson, P.
Aeberly, J. J.
Allan, C. D.
Allen, H. D.
Andel, F. J.
Arenberg, M. K.
Ashenhurst, H. S.
Bailey, J. H.
Baker, E. V.
Barrows, C. E.
Baumgardner, C. M.
Beery, C. E.
Bennett, P. D.
Bidwell, R. E.
Black, F. C.
Bloom, S. C.
Bolte, E. E.
Boswin, G. A.
Bracken, J. H.
Braun, L. T.
Brayton, W. M.
Broom, B. A.
Burke, G. B.
Burns, W. A.
Callaghan, P. F., Jr.
Calvert, N. W.
Carnahan, G. C.
Casey, B. L.
Casserly, T. D.
Chenoweth, W. H.
Claffey, E. J.
Clark, H. J.
Clow, M. T.
Cornell, H.
Coughlin, R. J.
Crawford, W. B.
Crone, C. E., Jr.
Currier, C. H.
Cutler, J. A.
Cutter, E. H.
Davis, H. H.
Davis, J. H.
Deland, C. W.
Dickinson, C. E.
Doherty, R.
Dresen, W. D.
Dunham, C. A.
Ebin, L.
Emmett, L. D.
Ensign, R. M.
Faber, G. S.

Finan, E. J.
Finan, J. J.
Fix, F. W., Jr.
Fleming, J. P.
Frank, J. M.
Funck, E. H.
Gardner, W., Jr.
Gaylord, F. H.
Gemeny, W. J.
Getschow, G. M.
Getschow, R. M.
Gibbs, F. C.
Gilmore, R. E.
Good, M. S.
Gordon, E. G.
Gossett, E. J.
Graves, C. C.
Graves, W. B.
Grebe, H. W.
Haas, S. L.
Haines, J. J.
Hale, J. F.
Halliday, L.
Hardinge, F.
Hart, H. M.
Harter, B. B.
Hartman, F. E.
Hattis, R. E.
Hayes, J. J.
Hayward, R. B.
Heck, G. L., Jr.
Heckel, E. P.
Hennings, W. A.
Herlihy, G. F.
Herlihy, J. J.
Hill, E. V.
Hillen, A. G.
Hoier, W. V.
Hoover, H. E.
Hornung, J. C.
Horton, H. F.
Howatt, J.
Howe, W. W.
Hubbard, G. W.
Impey, P. F.
Jackson, C. J.
Jenson, J. S.
Johns, H. B.
Johnson, C. W.
Johnson, D. H.
Jones, E. F.
Jones, M. P.
Keeney, F. P.
Kehm, A.
Kehm, H. S.
Kirk, G. H.
Kreissl, H. G.
Lagodzinski, H. J.
Lang, L. P.
Larson, J. M.
Larson, W. C.
Lathrop, Dr. E. C.
Lautenschlager, F.
Lees, H. K.
Lenone, J. M.
Lewis, S. R.
Lippman, O. S.
Luce, G. D., Jr.
Maier, H. F.
Malone, D. G.
Marschall, P. J.
Martin, O. W.
Matchett, J. C.
Mathis, E.
Mathis, H.
Mathis, J. W.
Mathy, J., Jr.
Mauer, W. J.
May, A. O.
McCarthy, B. J.
McCauley, J. H.
McClellan, J. E.
McDonnell, E. N.
McEvoy, W. J.
McFarland, W. P.
McLelland, H. B.

Mehring, G.
Mertz, W. A.
Miller, F. A.
Miller, J. E.
Miller, R. T.
Milliken, J. H.
Monaghan, T. H.
Monroe, H. E.
Montgomery, W. R.
Moore, R. E.
Muth, H.
Nacey, H. M.
Narowetz, L. L., Jr.
Neiler, S. G.
Nelson, R. O.
Newport, C. F.
Nilson, A.
Nilson, K. A.
Norman, M. A.
Nulson, C. A.
O'Brien, J. H.
O'Connell, P. M.
Offen, B.
Olsen, C. F.
Olson, A. E.
Olson, B.
Orr, F. B.
Pence, M. D.
Pitcher, L. J.
Pope, S. A.
Pope, W. A.
Powers, F. W.
Prentice, O. J.
Prohaska, E. C.
Reid, H. P.
Ries, L. S.
Rietz, E. W.
Rosenbach, R. G.
Rottmayer, S. I.
Russell, E. A.
Saunders, J. C.
Sawhill, R. V.
Scheidecker, D. B.
Schwab, Q. D.
Schweim, H. J.
Seelig, L.
Seltzer, A. P.
Shufelt, H. M.
Shultz, E.
Small, J. D.
Snider, L. A.
Soper, I. N.
Spafford, L. B.
Sprague, F. H.
Stackhouse, R. M.
Stannard, J. M.
Stedman, C. N.
Stiles, H. L.
Stockenberg, R.
Sutcliffe, A. G.
Thinn, C. A.
Thomas, R. H.
Truitt, J. E.
Trumbo, S. M.
Valiquet, H. H.
Walker, G. E.
Walsh, A. F.
Walters, V.
Walters, W. T.
Walther, V. H.
Washington, L. W.
Watson, J. H.
Weil, M.
Weil, M. I.
Weinshank, H. T.
Weinshank, T.
Weixel, A. L.
Widdicombe, R. A.
Wiersig, R. H.
Wittleder, E. A.
Yardley, R. W.
Zack, H. J.

Decatur—
Shorb, W. A.

Evanston—
Bennett, R. E.
Bergner, W. G.
Kilby, R. E.
McIlvaine, J. H.
Thomas, H. G.
Vernon, J. R.

Joliet—
Menk, R. W.
Russell, W. B.

Kewanee—
Bronson, C. E.
Dickson, R. B.
Hartman, J. M.
Pursell, H. E.

La Grange—
Eaton, B. K.
Linn, H. R.

Moline—
Beling, E. H.
Munson, M. G.
Nelson, H. W.
Nordine, L. F.
Otis, G. E.
Tyler, F. T.

Oak Park—
Alexander, A. D.
Barnes, R. B.
Blanding, G. H.
May, E. A.
Muir, G. A.
Uhlhorn, W. J.

Park Ridge—
Gross, R. A.
McGregor, G. H.
Spielmann, G. P.

Peoria—
Meyer, F. L.
Robb, J. M.

Rockford—
Merwin, G. E.

Rock Island—
Nelson, R. H.

Springfield—
Peterson, L. J.

Summit—
Ross, J. F.

Urbana—
Bennett, G. G.
Kratz, A. P.
Willard, A. C.

Waukegan—
Collette, J. R.
Turner, J. W.

Wilmette—
Graham, W. D.

Winnetka—
Brown, A. P.
Ellis, E. E.
Martin, A. B.

Zion—
Koetz, L.

INDIANA

Elkhart—
Miller, L. B.
Shreiner, D. C.

Evansville—
Legeman, R. E.

Fort Wayne—
Noland, L. U.
Noland, R. W.

Hammond—
Schram, W. W.

Indianapolis—
Ammerman, C. R.
Ascher, N. C.
Bevington, W. C.
Callon, H., Jr.
Cotton, R. M.
DeHaven, I. C.
Edwards, R. H.
Fenstermaker, S. E.
Freyn, H. L.
Hagedon, C. H.
Hayes, J. G.
Heidenreich, G.
Jackson, G. O.
Jackson, J. O.
McMahon, T. W.
Neal, H. W.
Perham, S. H.
Poehner, R. E.
Rotz, J. M.
Shipp, C. C.
Stitt, H. B.
Strong, E. A., Jr.
Van Alstyne, R. F.
Voorhees, G. A.
Warren, C. N.
Whittington, W. P.
Williams, G. M.

Jeffersonville—
Hancock, J. R.

Lafayette—
Hotchkiss, C. H. B.
Orth, J. W.

La Porte—
Shrock, J. H.

Michigan City—
Stockwell, W. R.

Muncie—
Hutzel, M. H.
Hutzel, V. C.

Peru—
Pyle, J. W.
Thrush, H. A.

Richmond—
Stevenson, M. E.

South Bend—
Leusch, V. W.

Terre Haute—
Prox, R. F.

West Lafayette—
Hoffman, J. D.

IOWA

Ackley—
Nelson, G. O.

Cedar Rapids—
Moore, R. F.
Motejl, J. A.

Des Moines—
Sommers, W. S.

Le Mars—
Mathey, N. J.

Sioux City—
Hagan, W. V.
Orr, M. J.

Waterloo—
Winterbottom, J. W.

KANSAS

Emporia—
Burnap, C. W.

Hutchinson —
Hertz, H. P.
Paulsen, C. E.
Stevens, H. L.

Independence—
Sellars, F. J.

Kansas City—
Betz, H. D.

Lindsborg—
Holmberg, J. A.

Wichita—
Johnson, R. B.
O'Connor, J. M.

KENTUCKY

Lexington—
Anderson, F. P.
Evans, H.
Ingels, M.
O'Bannon, L. S.

Louisville—
Birkholz, H. E.
Helburn, I. B.
Murphy, H. C.
Reed, W. M.
Shrum, A. T.

MAINE

Belfast—
Goodhue, A. P.

Portland—
Fels, A. B.
Merrill, C. J.

Presque Isle—
Noyes, G. T.

Woodfords—
Eaton, P.
Haskell, B. E.

MARYLAND

Baltimore—
Adams, H.
Baker, C. H.
Collier, W. I.
Dorsey, F. C.
Eisert, H.
Erickson, H. A.
Griffin, J. J.
Leilich, R. L.
McCrea, L. W.
Posey, J.
Reeder, C. L.
Thain, A. E.
Vance, L. G.
Williams, J. M., Jr.

Bethesda—
Stock, E. L.

Ellicott City—
Tibbets, J. C.

Hagerstown—
Dorfan, M. I.

Rockville—
Brunett, A. L.

Towson—
Seiter, J. E.

MASSACHUSETTS

Arlington—
Shaw, N. J. H.
Whitaker, E. C.

Boston—
Abboud, A.
Ahearn, W. J.
Bartlett, A. C.
Barton, R. E.
Boyden, D. S.
Boynton, D. W.
Brinton, J. W.
Brooks, T. C.
Brown, R. H.
Bryant, Dr. A. G.
Cooper, F. I.
Drinker, P.
Dussossoit, E. A.
Ehrenzeller, A.
Flemings, J. A.
Foulds, P. A.
Gifford, R. F.
Gilmore, F. P.
Gleason, G. H.
Goodrich, C. F.
Hilliard, C. E.
Hubbard, A.
Hubbard, A., Jr.
Jones, W. T.
Kelley, J. J.
Kellogg, A.
Kimball, C. W.
McCoy, T. F.
McKenna, W. N.
McLean, I. D.
McMurrer, L. J.
Moulton, D.
Mower, W. P.
Myrick, J. W. H.
Osborne, M. M.
Pocock, P. C.
Shaw, R. E.
Stetson, L. R.
Stone, E. R.
Swaney, C. R.
Thompson, R. C.
Tilden, E. E.
Tuttle, J. F.
Underhill, W. W.
Wade, N. S.
Webb, J. S.
Whittemore, E. H.
Whitten, H. E.
Whitten, H. W.
Wilson, H. M.
Yaglou, C. P.

Brighton—
Schanze, A. G.

Cambridge—
Baker, R. H.
Cox, C. J.
Donnelly, W. C.
Flint, C. T.
Haddock, I. T.
Heath, F. R.
Klonower, A. A.
Matthews, C. R.

Charlestown—
Herrick, D. A.

Chestnut Hill—
Cummings, C. H.

Dorchester—
Brown, M.
Hosterman, C. O.
Plunkett, J. H.
Swan, T. J.

East Weymouth—
Eaton, R.

Fitchburg—
Dolan, W. H., Jr.
Illig, W. R.
Karlson, A. F.

Framingham—
Fitch, W. S.

Holbrook—
Nason, G. L.

Hyde Park—
Ellis, F. R.
Scheibel, A. H.

Lawrence—
Bride, W. T.

Leominster—
Kern, R. T.

Lynn—
Feehan, J. B.
Morgan, F. H.
Pool, S. H.
Reardon, J. A.

Malden—
McDonald, J. J.
Smallman, W. T.

Medford—
Dane, I. S.
Suits, G. A.

Melrose—
Franklin, R. S.
Kirmes, E. W.
Pierce, E. F., Jr.
Smallman, E. W.

Milton—
Mitchell, C. H.

Newton—
Cousens, W. S.

Pittsfield—
Robbins, L. G.

Reading—
Ingalls, F. D. B.

Roxbury—
Richard, I. T.

South Weymouth—
Berchtold, E. W.

Springfield—
Leland, W. B.

Watertown—
Wiegner, H. B.

Wellesley Hills—
Gilling, W. F.

West Newton—
Place, H. R.

Weymouth—
Clough, L.

Woburn—
Parker, P.

Wollaston—
Hodgdon, H. A.
Shaw, E.

Worcester—
Dix, H. M.
Hawes, H. R.
Standish, M.

MICHIGAN

Ann Arbor—
Backus, T. H. L.
Emswiler, J. E.
Hutzel, A. F.

Detroit—
Akers, G. W.
Ames, C. F.
Armstrong, H. M.
Baldwin, W. H.
Bishop, F. R.
Blackmore, F. H.
Boales, W. G.
Brown, C.
Clark, E. H.
Collamore, R.
Connell, R. F.
Coon, T. E.
Corbin, W. E.
Cummings, C. A.
Cummins, G. H.
Dauch, E. O.
Davis, L. J.
Decker, E. M.
Degan, J. E.
Dillman, E. J.
Donohue, E. S.
Doody, C. A.
Dubry, E. E.
Eggleston, L. W.
Feely, F. J.
Fortune, J. R.
Fuller, J. L.
Gallaher, J. E.
Gaulin, R. P.
Giguere, G. H.
Green, J. E.
Hamlin, H. A.
Harms, W. T.
Harrigan, E. M.
Heydon, C. G.
Hill, N. J.
Hogan, E. L.
Hubbard, N. B.
Johnson, F. W.
Johnson, H. S.
Johnston, W. B.
Killian, M. A.
Kilner, J. S.
Knight, A. B.
Lance, J. F.
Linhard, H. V.
Little, E. R.
McColl, J. R.
McConachie, L. L.
McConner, C. R.
McGeorge, R. H.
McIntire, J. F.
McLean, D.
McNair, E. E.
Meyer, J. W.
Miller, H. N.
Miller, J. F. G.

Milward, R. K.
Monroe, L. O.
Morgan, C. S.
Morse, C. T.
Paetz, H. E.
Parrott, L. G.
Partlan, J. W.
Peckham, R. R.
Phelps, H. R.
Pittelkow, A. G.
Purcell, F. C.
Purcell, R. E.
Randall, W. C.
Roberts, J. H.
Roney, T. G.
Rowe, W. A.
St. John, J. S.
Saulson, S.
Shepstone, O.
Shuell, F. W.
Smith, G. W.
Smith, L. L.
Snell, E.
Snyder, J. W.
Soderberg, C. H.
Spitzley, R. L.
Spurgeon, J. H.
Stephen, H. M.
Verner, W. F.
Walker, J. H.
Walton, H. L.
Whelan, W. J.
Whiteley, J.
Wigle, B. M.
Wilde, R. S. M.
Williamson, A. H.
Winans, G. D.
Woolley, T. R.
Ziel, H. E.
Zorb, H. P.

Grand Rapids—
Alexander, C. H.
Bradfield, W. W.
Carman, G. G.
Carroll, W. J.
Jaynes, E. L.

Highland Park—
Foster, W. M.

Holland—
Cherven, V. W.

Kalamazoo—
Blaney, C. A.
Kersjes, W.

Lansing—
Distel, F.

Marcellus—
Henrich, G. A.

Pleasant Ridge—
Blessed, W. A.
Petherick, D. H.

Plymouth—
Campbell, J. M.

Saginaw—
Swartwout, J. D.

MINNESOTA

Cloquet—
Backstrom, R. E.
Spafford, A.

Duluth—
Foster, C.
Whitnah, C. S.

Minneapolis—
Andresen, A. W.
Barnum, M. C.
Betts, H. M.
Bjerken, M. H.
Bradford, H. H.
Brown, J. H.
Burns, E. J.
Burritt, C. G.
Cash, T. T.
Cowles, B. E.
Dahlstrom, G. A.
Forfar, D. M.
Gerrish, H. E.
Gordon, E. B., Jr.
Hanchett, J. H.
Hanson, L. C.
Harris, J. B.
Hasey, C. E.
Helstrom, H. G.
Huch, A. J.
Kuempel, L. L.
Martenis, J. V.
Morgan, G. C.
Mosher, R. B.
Parks, W. N.
Probst, A. H.
Rowley, F. B.
Sanford, A. L.
Sperzel, H. J.
Uhl, E. J.
Uhl, W. F.
Zingsheim, G. G.

Owatonna—
Clarkson, W. B.

Rochester—
Adams, N. D.

St. Paul—
Anderson, P. E.
Blackshaw, J. L.
Buenger, A.
Challman, S. A.
Gausman, C. E.
Heagler, J. M.
Hires, C. R.
Jones, E. F.
Lewis, E. B.
Otto, R. W.
Ruff, D. C.
Skagerberg, R.
Wagner, A. M.
Winterer, A. V.
Winterer, F. C.
Wunderlich, M. S.

Wayzata—
Mikesh, J. J.

MISSISSIPPI

Jackson—
Paine, K. A.

MISSOURI

Independence—
Cook, B. F.

Kansas City—
Arthur, J. M., Jr.
Burton, C. A.
Caleb, D.
Campbell, E. K.
Carr, C. H.
Clegg, C.
Cox, W. F.
Dodds, F. F.
Downes, N. W.
Dunlap, R. L.
Fehlig, J. B.
Gillham, W. E.
Henrici, H. C.
Herold, C. W.
Hitchcock, F. P.
Jones, E.
Kitchen, F. A.
Kitchen, J. H.
Lewis, J. G.
Mason, R. B.
Millis, L. W.
Natkin, B.
Naylor, B. C.
Nottberg, H. J.
Painter, D. H.
Pines, S.
Plass, C. W.
Qualtrough, B. F.
Russell, W. A.
Sheppard, F. A.
Weiss, C. A.
Woodling, M. D.
Worm, A.
Wright, H. H.

Kirkwood—
Graves, R. E.
McMorran, F. J.

Liberty—
Dudfield, A.

St. Louis—
Baetz, H.
Balsinger, H. D.
Barnes, E. R.
Bayse, H. V.
Bowers, J. S.
Bradley, E. P.
Bradley, J. T.
Branigan, H. L.
Browning, H. K.
Buder, C. G.
Butler, C. W.
Carlson, E. E.
Cook, C. D.
Cooper, J. W.
Davis, C. R.
DeNeille, J. L.
Edwards, D. F.
Eichler, A.
Evleth, E. B.
Falvey, J. D.
Ferguson, R. R.
Foster, J. M.
Gale, T. J. G.
Gallaher, A. J.
Halley, W. H.
Harris, H. W.
Helwig, G. A.
Hester, T. J.
Humphreys, A. E.
Kaysing, H. C.
Kent, J. K.
Lane, A. M.
Langenberg, E. B.
Lathers, V. M.
Meara, J. J.
Merrell, S. A.
Messmer, G. E.
Metcalf, R. H.
Moon, L. W.
Niestrath, W. H.
Picker, F. C.
Pickett, C. A.
Quentin, E. H.
Rickley, F. A.
Robertson, J. M.
Rosebrough, R. M.
Rossman, V. D.
Russell, W. L. A.
Sachleben, E. H.
Schukai, W.
Schulze, B. H.
Smith, R. J.
Sodemann, P. W.
Sodemann, W. C. B.
Stammer, E. L.
Steckhan, L.
Thomsen, W. T.
Walters, A. L.
White, E. A.
Wolff, O. H.

Springfield—
Cooper, H.

Webster Groves—
Manahan, J. E.
Myers, G. W. F.

MONTANA

Big Timber—
Strickland, A. W.

Billings—
Cohagen, C. C.
Tooker, C. C.

Bozeman—
Bunnell, E. W.
Powers, F. I.

NEBRASKA

Scotts Bluff—
Davis, O. E.

NEW JERSEY

Atlantic City—
Strouse, S. B.

Bayonne—
Schwartz, J.

Belmar—
Merkel, F. P.

Bloomfield—
Hochuli, H. W.
Lau, A. S.

Camden—
Kappel, G. W. A.
Kohr, R. K.
Lanning, E. K.
Strandwitz, W. J.
Swift, C. K.
Webster, E. K.
Webster, W.
Webster, W., Jr.

Cranford—
Lynch, G. D.
Terrell, H. A.

East Orange—
Grahn, V. F.
Hillen, W. G.
Hunter, C. C.
Reilly, J. H.
Schroth, A. H.
Turno, W. G. W.

Elizabeth—
Cornwall, G. T.
Klube, J. O.
Lyman, S. E.
Nesdahl, E.
Pearce, C. E.
Wheller, H. S.
Woodlock, W. M.

Emerson—
Blume, F. J., Jr.

Essex Fells—
Stacey, A. E., Jr.

Fair Haven—
Smith, H. P.

Glen Rock—
Hall, C. H.

Grantwood—
Butler, P. D.

Haddonfield—
Dobbs, C. E.
Jones, R. E.

Harrington Park—
Thuem, E. A.

Hasbrouck Heights—
Goodwin, S. L.

Hawthorne—
Lawton, F. C.

Irvington—
Ellis, W. H.
Freas, R. B.
Wells, H. N.

Jersey City—
Calahan, J.
Driscoll, W. H.
Jones, H. L.
Ritchie, W.
Walterthum, J. J.

Jobstown—
Allinson, O. H.

Kearny—
Long, D. R.
Siebs, C. T.
Vogelbach, O.

Lyndhurst—
Ehrlich, M. W.

Maplewood—
Evans, W. A.
Smith, M. S.

Merchantville—
Binder, C. G.

Montclair—
Bentz, H.
Holbrook, F. M.

Mountain Lakes—
Bolling, E.

Newark—
Bermel, A. H.
Bryant, P. J.
Carrier, W. H.
Day, V. S.
Gabelmann, P. E.
Gifford, E. W.
Heiles, F. C.
Leinroth, J. P.
Lewis, L. L.
Lyle, J. I.
Noble, M.
Nolan, J. J., Jr.
Rydell, C. A.
Soule, L. C.
West, P.
Worsham, H.

Nutley—
Matthiessen, H. G. F.

Oaklyn—
Driggs, L. L.

Palmyra—
Schopp, W. J.

Passaic—
Boeker, C. H.
Hankin, R.
Harding, R. M.
Morris, C. R.

Paterson—
Pryor, F. L.

Plainfield—
MacDougall, B. W.
Tobin, G. J.

Princeton—
Black, J. J. A.

Ridgefield Park—
Davis, A. C.

Ridgewood—
Forgee, F. A.

Riverton—
Bilyeu, W. F.
Brunt, T. B.

Short Hills—
Fouilhoux, J. A.

South Orange—
Hansen, C. C.

Teaneck—
Heebner, W. M.

Trenton—
Perlstein, S.

Union City—
Darton, A. W.
Taverna, F. F.

Verona—
Frutchey, M. P., Jr.

Woodridge—
Reynolds, T. W.

NEW YORK

Albany—
Murray, T. F.
Naden, L. J.
Ryan, H. J.
Steim, C. J., Jr.
Stevens, F. H.
Taggart, R. C.

Binghamton—
Folley, E. B.

Bronxville—
Barr, G. W.
Denholm, J. A., Jr.

Brooklyn—
Atwater, L. W.
Bampton, C. M.
Beatty, D. J.
Bender, C. P.
Bernhard, G.
Blest, F. S.
Crutchley, E., Jr.
Dill, H. O.
Doherty, J. A.
Dwyer, T. F.
Eells, H. B.
Emery, W. D.
Gardner, B. F.
Gornston, M. H.
Griffin, B. H.
Hanley, J. H., Jr.
Harrison, B. S.
Hinchman, E. G.
Janet, H. L.
Kreitner, W.
Lemmerman, C. W.
Lindeman, H.
Mandeville, E. W.
McCann, F. G.
McKiever, W. H.
Moss, E.
Musaus, J., Jr.
Phillips, F. W., Jr.
Richardson, F. J.
Ruppert, E. H.
Scollay, U. G.
Seward, P. H.
Shay, R. A.
Siegel, L.
Tisnower, W.
Tusch, W.
Vivarttas, E. A.
Walsh, J. F.
Ward, G. C.
Williamson, F. W.
Zibold, C. E.

Buffalo—
Ahlff, A. A.
Archer, F. S.
Ashton, D. W.
Beirn, J. U.
Beman, M. C.
Booth, C. A.
Bresnahan, J. J.
Bulkeley, C. A.
Burke, F. H.
Castin, L. N.
Cherry, L. A.
Cheyney, C. C.
Clucas, W. F.
Criqui, A. A.
Danforth, N. L.
Davis, J.
Dempsey, H. P.
Dyer, O. K.
Evans, C. A.
Ewing, D. R.
Farnham, R.
Farrar, C. W.
Frank, Mrs. O. E.
Frankel, G.
Fraser, W. G.
Gauvin, L. G.
Harding, L. A.
Hedley, P. S.
Hirschman, W. F.
Jackson, M. S.
Johnson, E. E.
Johnson, W. F.
Kamman, A. R.
Landers, J. J.
Love, C. H.
Madison, R. D.
Mahoney, D. J.
Moran, R. J.
Mosher, C. H.
Padginton, G.
Quigley, W. J.
Roebuck, W., Jr.
Schank, G. E.
Scheer, F. W.
Snyder, J. S.
Thornton, R. T.
Tinker, A. K.
Wendt, E. F.
Yager, J. J.

Elmira—
Davis, B. C.
Frutchy, A. E.
McGlenn, G. R.

Geneva—
Herendeen, F. W.
Smith, S. S.

Herkimer—
Ertman, B. R.

Irvington-on-Hudson—
Bastedo, A. E.

Ithaca—
Sawdon, W. M.
Williams, J. W.

Jamestown—
Sharp, F. H.

Kenmore—
Bliss, S. C.
Riley, D. H.

Larchmont—
Dillon, H. R.
Downe, E. R.
Gaylor, W. S.
Kingsley, E. A.

Lockport—
Porzel, J.

Mamaroneck—
Benson, B. A.

Millbrook—
Pizie, S. G.

Morton—
Stangland, B. F.

Mt. Vernon—
Bishop, C. R.
Hunt, R. B.
Obert, C. W.

New Rochelle—
Dailey, J. F.
Kuhlmann, R.
Senior, R. L.

New York City—
Abrams, A.
Addams, H.
Adler, A. A.
Alvord, A. M.
Armagnac, A. S.
Armspach, O. W.
Bachler, L. J.
Baird, F. X.
Barth, H. E.
Baum, A. L.
Beebe, F. E. W.
Bennett, I. T.
Bennitt, G. E.
Berman, L. K.
Binder, I.
Birch, H. R.
Blackburn, E. C., Jr. (Hempstead, L. I.)
Blackman, A. O.
Blackmore, J. J.
Bock, B.
Bolton, R. P.
Bondy, W. S.
Booth, H. N.
Brassington, A. F. (Port Richmond, S. I.)
Browne, A. L.
Buck, L.
Buensod, A. C.
Campbell, F. B.
Carpenter, R. H.
Chase, J. M.
Close, P. D.
Cosgrove, W. M.
Crone, T. E.
Cumming, R. W.
Cunningham, N.
Dailey, J. A.
Darts, J. A.
DePalma, J. R. (Woodhaven, L. I.)
Donnelly, R.
Donoghue, J. J.
Dornheim, G. A. (Long Island City)
Duff, K.
Duffield, T. J.
Durand, W. L.
Eadie, J. G.
Easterbrooks, C. C.
Eastwood, H. F.
Ellison, J. H. (Freeport, L. I.)
Ely, F. E.
Emerson, R. R.
Engle, A.
Fansler, P. E.
Faulkner, D. H. (Hempstead, L. I.)
Fay, F. C.
Feldman, A. M.
Fife, G. D.
Fleisher, W. L.
Flemming, W. L.
Flink, C. H.
Friedman, A.
Friedman, F. J.
Gast, C. (Rockville Center, L. I.)
Giannini, A. C.
Glore, E. F.
Goldberg, H. M.
Goldschmidt, O. E.
Gombers, H. B.
Goodnow, W. F.
Grant, A. E.
Grant, W. A.
Grill, G. E.
Harbula, M. G.
Haynes, C. V.
Heatherton, J. M.
Hedges, H. B.
Hettinger, H. (Floral Park, L. I.)
Hills, A. H.
Hinkle, E. C. (Hempstead, L. I.)
Hinrichsen, A. F.
Hoffman, C. S.
Hook, M. G.
Howell, F. B.
Hyman, W. M.
Hynes, L. P.
Issertell, H. G.
Jacobs, B.
Jacobus, Dr. D. S.
Jalien, J. J.
Johnsen, H. (Dongan Hills, S. I.)
Johnson, E. B. (West New Brighton, S. I.)
Johnston, W. H.
Keasbey, A. P.
Keenan, P. F.
Kellogg, T. M.
Keplinger, W. L.
Keyes, R. E.
Kiewitz, A. A. (Astoria, L. I.)
Kiewitz, C. (Floral Park, L. I.)
Kimball, D. D.
Kirk, L. G.
Knowles, A. F.
Koithan, W. S.
LeBeau, J. F. (Jamaica, L. I.)
LeCompte, W. G.
Lennon, J. O.
Longwell, H. E.
Lucke, C. E.
Lyle, E. T.
Maier, G. M.
Marshall, H. H.
Martin, G. W.
McCormack, E. T.
Meyer, H. C., Jr.
Mickiewicz, S. J.
Miller, C. A.
Miller, R. B.
Morrill, R. D.
Munder, J. F., Jr.
Munier, L. L.
Munro, E. A.
Murphy, E. T.
Murphy, J. R.
Murphy, W. A.
Neale, L. I.
Neideck, A. A.
Nelson, G. A.
Nichols, G. B.
Nicol, N. C.
Oaks, O. O.
O'Connell, M.
O'Donnell T. J.
Odrobina, S. R. (Long Island City)
Offner, A. J.
Olvany, W. J.
Osborne, W. J.
Parkhill, D.
Parter, S. C.
Patorno, S. A. S.
Paulding, L. G.
Peacock, J. K.
Pease, H. H.
Pfeiffer, B. J.
Pfuhler, J. L. (West New Brighton, S. I.)
Pihlman, A. A.
Pinder, P. H.
Pine, M. (Jamaica, L. I.)
Place, C. R.
Presdee, C. W.
Pryor, R. W., Jr.
Purdy, R. B.
Purinton, D. J.
Quirk, C. H.
Raisler, S.
Ralston, L. T. M.
Reed, J. F.
Reynolds, W. V.
Rice, J. A. (Gibson, L. I.)
Richardson, D. R.
Riley, C. L.
Ritchie, E. J.
Ritter, A.
Rodman, R. W.
Rooney, M. A.
Rosenberg, P.
Ross, J. O.
Rothrock, J. T.
Ruggles, R. F. (Tompkinsville, S. I.)
Russell, W. A.
Samuels, S.
Sawade, C. A.
Schloss, N. L.
Schmidt, G. G.
Schneider, C.
Schoepflin, P. H.
Schunk, T. (Quogue, L. I.)
Scott, C. E.
Scott, E. A.
Scott, G. M.
Seelig, A. E.
Sellman, N. T.
Simpson, W. A.
Sklenarik, L. (Long Island City)
Smith, J. C.
Smith, P. C., Jr. (Northport, L. I.)
Spooner, H. R. (Jamaica, L. I.)
Stanton, G. W.
Staples, W. H.
Steinke, G. B.
Steinmuller, J. M. (Long Island City)
Stern, H. R.
Still, F. R.
Strock, C.
Sullivan, D. A.
Swain, W. A.
Sweeney, S. H.
Tallmadge, W.
Taylor, J. H. (Queens Village, L. I.)
Thomson, T. N. (Huntington, L. I.)
Timmis, W. W. (Glen Cove, L. I.)
Tucker, F. N.
Tyler, R. D.
Van Norden, E. M.
Vogt, J. H.
Waechter, H. P. (Tompkinsville, L. I.)
Walker, W. K.
Wallace, G. J. (Elmhurst, L. I.)
Wallace, W. M., Jr. (Hollis, L. I.)
Walsh, J. H.
Walsh, M.
Watters, P. J. (Port Richmond, S. I.)
West, B. F.
White, E. S.
Whitelaw, H. L.
Willis, R. C.
Wilson, F. A. (Bellaire, L. I.)
Wolff, R. A.
Wolfsfeld, C. F. (Bayside, L. I.)
Yockel, T. J.

North Tarrytown—
Weiss, A. P.

Ogdensburg—
Skelly, J. F.

Poughkeepsie—
Doherty, J. J.

Rochester—
Axeman, J. E.
Beasom, G. R.
Coe, I. B.
Coe, R. T.
Devendorf, W. F.
DeWolf, R. D.
Dobson, G. G.
Grau, E. R.
Hakes, L. M.
Haskins, A. L.
Sheldon, N. E.
Weider, F. J.
Welsh, H. S.
Wilder, E. L.
Wiley, C. S.

Rome—
Lynch, W. L.
Steele, M. G.

Rye—
Donovan, J. E.

Saranac Lake—
Miller, P.

Scarsdale—
Fiedler, H. W.
Grotz, A. B.

Schenectady—
Strachan, J. S.
Vogel, A.
Welch, L. A., Jr.

Snyder—
Langley, F. P.

Syracuse—
Acheson, A. R.
Bradley, R. H.
Breneman, R. B.
Dennis, C. K.
Ormsby, H. K., Jr.
Ryen, M.

Troy—
Wilson, C. H.

Utica—
Brandeles, H. J.
Hamjy, P. W.
Hughes, W. C.
Schneider, P. W.
Steinhorst, T. F.

Valhalla—
Mehne, C. A.

White Plains—
Callahan, T. H.
Newcomb, R.

Williamsville—
Hutzel, H. F.

Yonkers—
Brabbée, Dr. C. W.
Goerg, B.
Kelly, J. G.
Rainger, W. F.
Ullman, H. G.
Zuhlke, W. R.

NORTH CAROLINA

Charlotte—
Brandt, E. H., Jr.
Christian, C. W.

Greensboro—
MacKenzie, B.

High Point—
Gray, W. E.

Weldon—
Chappell, T. A.

Winston-Salem—
Bahnson, F. F.

OHIO

Akron—
Humphrey, D. E.
McClenathan, R.
Thatcher, G. S.

Canton—
Williams, O. L.

Cincinnati—
Blomfeldt, A. A.
Bostain, J. C.
Doyle, W. J.
Green, W. C.
Grier, W.
Houliston, G. B.
Kiefer, C. J.
Kitchell, H. N.
Royer, E. B.
Sproull, H. E.
True, J. E.
Wright, K. A.

Cleveland—
Bailey, E. P., Jr.
Benedict, E. R.
Beyer, J. E.
Bogardus, G. W.
Bridges, F. G.
Brueggeman, A. R.
Colby, C. W.
Deex, C. J.
Eveleth, C. F.
Farley, J. W.
Gottwald, C.
Greene, W. C.
Harrison, J. M.
Harvey, L. C.
Heinle, E. L.
Kammerer, W. C.
Kinner, J. E.
Kissick, J. J.
Klie, W.
McLeish, W. S.
Mason, J. J.
Matzen, H. B.
Miles, J. C.
Morris, F. H.
Neitzel, C. W.
Quay, D. M.
Rather, M. F.
Repp, H. L.
Roemer, J.
St. Clair, C. W.
Titus, M. S.
Van Sickle, W. B.
Weager, T. A.
Wise, F. W.

Cleveland Heights—
Davis, R. G.

Columbus—
Babbitt, E. C.
Brown, A. I.
Lawson, W. I.
Seiders, J. T.
Wheeler, O. J.
Williams, A. W.

Dayton—
Gibbons, M. J., Jr.
Haas, W.
Hoersting, F. J.

East Cleveland—
Nobis, H. M.
Stark, W. E.

Kent—
Stanford, L. E.

Lakewood—
Maurer, E. D.
Rehling, H. F.

Mansfield—
Barnsteiner, A.

Painesville—
Hobbs, J. C.

Ravenna—
Franzheim, G. W.

Springfield—
Hart, T. H.

Toledo—
Baker, H. C.
Bryce, S. D.
Mandel, H. J.
Rogers, A. C.
Vermere, E. J.

Youngstown—
Choffin, C. C.

OKLAHOMA

Oklahoma City—
Dolan, R. G.
Loeffler, F. X.
Patton, R. L.
Rae, T. W.
Thomas, B. A.

Tulsa—
Jones, E.

OREGON

La Grande—
Anderson, S. A., Jr.

PENNSYLVANIA

Allentown—
Buel, H. G.
Hersh, G. W.
Korn, C. B.

Ardmore—
Hires, J. E.
Whelan, W. F.

Baden—
McCreary, J. L.

Beaver Falls—
Van Alen, W. T.

Berwyn—
Sewell, J. M.

Boyertown—
King, T.

Bradford—
Hellstrom, J.
Paterson, F. C., Jr.

Bridgeport—
Abel, D. M.
Arko, F. W.
Holton, J. H.
Longenecker, H. J.

Chambersburg—
Kottcamp, H. A.
Mehaffey, W. C.

Chester—
Boyd, W. R.

Clarks Green—
Walker, G. F.

Cynwyd—
Smith, W. F.

Drexel Hill—Del. Co.
Jones, L. T.
Kriebel, J. H.
Rice, W. W.

Drexel Park—Del. Co.
Eckardt, C. A. T.

Erie—
Mayer, R. S.

Forty Fort—
Grossman, H. E.

Germantown—
Tomlinson, M. C. W.

Glenshaw—
McEllroy, G. S.

Harrisburg—
Degnan, T. J.
Eicher, Dr. H. C.
Fisher, E. L.
Geiger, I. H.
Lutz, J. H., Jr.
Schimmel, F. W.
Selig, E. T.
Weitzel, R. D.

Haverford—
Black, E. N.
Kellogg, H. D.

Hazelton—
Sherry, R. W.

Holmesburg Junction—
Nesbitt, A. J.
Nesbitt, J. J.

Jenkinstown—
Slight, I.

Johnstown—
Novotney, T. A.
Rinkenberger, G.

Lancaster—
Grossman, H. M.
Huzzard, E. C.
Jones, A.
Lloyd, E. C.
Schrader, C. C.

Lansdowne—
Myers, J. E.
Pennell, S. H.

McKeesport—
Dugan, T. M.

Millvale—
Staud, C. J.

New Castle—
Eckles, R. A.

Newton Square—
Del. Co.
Ramsay, H. W.

Norristown—
Bolsinger, R. C.
Frost, R. V.
Gormly, P.
Hucker, J. H.

Oil City—
Heagerty, W. H.

Philadelphia—
Adams, B.
Alt, H. L.
Anderson, C. A.
Arnold, R. S.
Aronson, H. H.
Bachler, H. C.
Bartlett, C. E.
Bauer, H. C.
Beahm, R. B.
Black, H. G.
Blankin, M. F.
Bogarty, H. S.
Boon, G.
Bornemann, W. A.
Boyd, D. K.
Bozeman, R. W.
Braemer, W. G. R.
Breen, J. W.
Brogan, J. J.
Burt, J. E.
Carey, J. A.
Carstens, E.
Cassell, J. D.
Cavileer, J. V.
Clarkson, R. C., Jr.
Cooper, T. W.
Culbert, W. P.
Dambly, A. E.
Davidson, L. C.
Davidson, P. L.
Dingleman, C. S.
Dome, W. R.
Duemler, F. C.
Eagan, W. H.
Eakins, W.
Edgar, A. C.
Eichberg, W. R.
Elliot, E.
Feltwell, R. H.
Fest, L. T.
Fitz, J. C.
Fleming, T. C.
French, D. E.
Galligan, A. B.
Galligan, J. H.
Gant, H. P.
Gillett, M. C.
Glassey, J. W.
Gomersall, W. H.
Graham, C. D.
Gross, S.
Hackett, H. B.
Heckroth, H. H.
Hellerman, H. H.
Hess, H. L.
Hibbs, F. C.
Hirst, J. N.
Hoft, P. J.
Hopkin, W. E.
Houpt, G. A.
Huckel, F. J.
Hunger, R. F.
Hurley, J. C.
Ickeringill, J.
Jellett, S. A.
John, B. F.
Johnson, J. M.
Kappler, H. C.
Kauffman, R.
Kelble, F. R.
Kerney, T. F.
Keys, G. W.
Kipe, J. M.
Koch, H. O.
Kriebel, A. E.
Leahy, J. L.
Lewis, G. C.
Lewis, J. W.
Lewis, T.
Liner, J. J.
Locke, H. W.
Lord, F. R.
Lutz, P. R.
MacDade, A. H.
Matson, T.
Mayette, C. E.
McCarthy, C. J.
McClintock, A., Jr.
McClintock, A., Sr.
McClintock, J. L.
Mellon, J. T. J.
Mensing, F. D.
Meyer, J. W.
Miller, A. A.
Miller, H. F.
Miller, W. C.
Minnich, H. S.
Monday, C. E.
Morgan, R. C.
Mott, A. C., Jr.
Murphy, W. R.
Nelson, F., Jr.
Nusbaum, L.
O'Connell, E. D.
Patrick, H. M.
Patterson, D. F.
Peak, A. M.
Perkins, F. C.
Phillips, F. T.
Plewes, S. E.
Price, W. H., Jr.
Reilly, C. E.
Rettew, H. F.
Reuss, E. H., Jr.
Roberts, H. L.
Rugart, K.
Sabin, E. R.
Sanbern, E. N.
Scott, C. E.
Setzer, W. C.
Shanklin, A. P.
Sheffler, M.
Sommer, L. J., Jr.
Speckman, C. H.
Stearns, W. I.
Stone, G. F.
Strong, R. C.
Sutterley, W. W.
Taliaferro, R. R.
Thompson, W. P.
Timmis, P.
Tinker, W. E.
Walsh, J. A.
Walther, H. J.
Wandless, F. W.
Ward, L. T.
Wegmann, A.
Welamb, V. N.
Whitby, S. S.
White, C. F.
Why, H. B.
Wild, W. H.
Wilson, B. W.
Wilson, J. J.
Woolston, A. H.
Woolston, C. E.

Phoenixville—
Wilmot, C. S.

Pittsburgh—
Alcott, W. L.
Aston, J.
Beighel, H. A.
Benson, M. A.
Blackmore, G. C.
Blackmore, N. L.
Bowman, H. A.
Brauer, R.
Bushnell, C. D.
Chester, T.
Clark, W. H.
Comstock, G. M.
Dibble, S. E.
Digby, H. E.
Edwards, P. A.
English, A. T.
Evans, E. C.
Firsching, F. J.
Gunther, F. A.
Hanson, E. W.
Harper, S. H.
Heilman, R. H.
Hook, C. H.
Houghten, F. C.
Langdon, J. D.
McGinness, J. E.
McGuigan, L. A.
McIntosh, F. C.
McLaughlin, J. J.
McMurray, J.
Maginn, P. F.
Moore, H. L.
Morgan, J. S.
Morrow, C. F.
Nass, A. F.
Nicholls, P.
O'Neill, P.
Orr, H. B.
Rederer, B. S.
Richards, S. F.
Schley, A. A.
Speller, F. N.
Stanger, R. B.
Steen, J. M.
Stevenson, W. W.
Stitt, E. W.
Stokes, R. E.
Teague, W. W.
Tennant, R. J. J.
Walker, J. B.
Waters, G. G.
Weber, G. A.
Wheeler, C. W.
Zelditch, M.

Reading—
Luck, A. W.
Nicely, J. E.
Reese, H. L.
Stack, M. F.

Ridley—
Culbert, W. G.

Scranton—
Gilboy, J. P.
Saville, T. H.
Shaver, H. H.

Sewickley—
Black, G. E.

Shamokin—
Gortner, J. W.

Stroudsburg—
Kiefer, E. J., Jr.

Swissvale—
Timmerman, M. M.

Tamaqua—
Hardesty, A. L., Jr.

Upper Darby, P. O.—
Hackett, C. P.
Mervine, T. R.

Warren—
Schellhammer, A. L.

Washington—
McVehil, E. W.

Wilkinsburg—
Campbell, T. F.
Rasmussen, E.

Williamsport—
Chambers, W. E.
McLain, R. D.
Moltz, G. N.
Pfeiffer, J. F.

Wormleysburg—
Filson, F. E.
Miller, T. G.

York—
Hertzler, J. R.
Lindemuth, N. R.
Sowers, P. E.

Zelienople—
Eberle, C. F.

RHODE ISLAND

Pawtucket—
Martin, J. F.

Providence—
Coleman, J. B.
Gibbs, E. W.
Hartwell, J. C.
Husband, E. W.
McLaughlin, J. D.
Moulder, A. W.
Poole, E. F.

Washington—
Wilson, H. A.

TENNESSEE

Chattanooga—
Russell, H. C.

Memphis—
Allen, W. H
Bevil, A. T.
Brewster, D. R.

Nashville—
Brown, F.
Hailey, S. H.

TEXAS

Amarillo—
Burnett, E. S.
Helphingstein, O.

College Station—
Giesecke, F. E.

Dallas—
Chappell, R. E.
Moler, W. H.
Van Zandt, J. H.

Fort Worth—
Skinner, H. W.

Houston—
Barnes, A. F.

San Antonio—
Diver, M. L.
Ebert, W. A.
Reynolds, H. M.
Willis, W. J.

UTAH

Salt Lake City—
Cooper, A. W.

VERMONT

Burlington—
Austin, F. L.
Raine, J. J.

North Ferrisburg—
Breckenridge, L. P.

St. Albans—
Sturges, H. A.

VIRGINIA

Lynchburg—
Cleland, J. E.
Doering, F. L.
Wiley, E. C.
Wilson, E. J. F.

Norfolk—
Peebles, J. K., Jr.

Richmond—
Austin, W. E.
Beverley, R. C.
Carle, W. E.
Childress, W. L.
Johnston, J. A.
Livingston, B. B.
Schulz, H. I.

Roanoke—
Wash, W. P.

Staunton—
Moffett, W. S.

WASHINGTON

Spokane—
DeLong, Maj. H. B.
Nelson, R. L.

Yakima—
McCune, B. V.

Seattle—
Anderson, M.
Beggs, W. E.
Carsten, W. H.
Cox, W. W.
Dudley, W. L.
Early, G. D.
Eastwood, E. O.
Eckart, C. H.
Heath, S. C.
Hogaboom, H. R.
O'Connell, P. M.
Mallis, W.
Mann, C. P.
Ruddell, W. H.
Tennant, E. M.
Twist, C. F.
Weber, E. L.
Zokelt, C. G.

WEST VIRGINIA

Charleston—
Shanklin, J. A.
Shanklin, J. R.

Largent—
Donnelly, J. A.
Innes, Helen R.

Morgantown—
Zeck, A.

Wheeling—
Hare, E. S.
Schofield, T. J.

WISCONSIN

Eau Claire—
Grosvold, F. E.

Fond du Lac—
Ahern, T. L.

Fort Atkinson—
Shodron, J. G.

La Crosse—
Anderegg, R. H.
Johnson, T. R.
Miller, M. W.
Trane, R. N.

Madison—
Larson, G. L.
Nelson, D. W.
Plaenert, A. B.

Milwaukee—
Berghoefer, V. A.
Berringer, S. H.
Bowers, A. F.
Brown, W. H.
Cook, H. R.
Downey, P. C.
Ellis, H. W.
Goethel, A. C.
Haupt, H. F.
Jackson, C. H.
Jones, E. A.
Jung, J. S.
Juttner, O. J.
Knab, E. A.
Lovegren, H. M.
Meadows, F. H.
Miller, C. W.
Miller, H. M.
Mueller, P. E.
Noll, W. F.
Olson, R. G.
Ostrander, L. F.
Randolph, C. H.
Rice, C. J.
Richtmann, W. M.
Schwab, H. E.
Szekely, E.
Ver Halen, E. T.
Volk, J. H.
Weimer, F. G.
Wilson, W. H.
Wolf, J. C.
Worthing, E.

Racine—
Dixon, A. G.
Thomas, N. A.

Superior—
Eddy, W. H.

Wausau—
Bassler, E. M.

Wauwatosa—
Dannies, F. R.
Page, H. W.
Zuehlke, R.

West Allis—
Erickson, M. E.

Wisconsin Rapids—
Eron, L. J.

FOREIGN COUNTRIES

AUSTRALIA

Sidney—
Sands, C. C.

Melbourne—
Overton, S. H.

Malvern—
Swan, E. H.

BELGIUM

Brussels—
Mautsch, R. H.

CANADA

Calgary, Alberta—
Clarke, S. S.
Walker, A.

Edmonton, Alberta—
Kelly, H.
Latham, G.

Fairville, N. B.—
Campbell, J. P.

Galt, Ont.—
Evans, J.
McCaffrey, H. G.

Halifax, N. S.—
Eagar, R. F.

Islington, Ont.—
Wilson, G. T.

Kingston, Ont.—
Arkley, L. M.
Druce, J. J.

London, Ont.—
Collver, G. L.

Montreal, P. Q.—
Darling, A. B.
Higgins, T. J.
Kastello, A.
LaPrairie, C.
Linton, J. P.
McGrail, T. E.
Osborne, G. H.
Wiggs, G. L.

Ottawa, Ont.—
Gray, G. A.

Quebec—
Dubé, W.

Sault Ste. Marie—
Wilson, W. S.

Toronto, Ont.—
Addy, E.
Angus, H. H.
Birrell, A. L.
Blackhall, W. R.
Boddington, W. P.
Church, H. J.
Clifton, W. F.
Cole, G. E.
Dickey, A. J.
Dolan, E. M.
Flett, H. R.
Gaby, F. A.
Griffiths, M. R.
Gurney, E. H.
Harrington, C.
Henion, H. D.
Leitch, A. S.
MacKenzie, J. J.
McHenry, R. W.
McMichael, P.
Millar, R. J.
Moore, H. S.
O'Neill, J. W.
Paterson, J. S.
Peterkin, S. MacC.
Playfair, G. A.
Purdy, A. K.
Shears, M. W.
Sheffield, E. B.
Sheppard, W. G.
Tabbiner, H.
Thomas, M. F.
Thompson, W. J.
Watson, M. B.
Wood, J. S.

Vancouver, B. C.—
Blake, A. H.
Givin, A. W.
Johnston, R. E.
Leek, W.
McCreery, H. J.

Victoria, B. C.—
Sheret, A.

Windsor, Ont.—
Howell, L.
Pennock, W. B.

Winnipeg, Man.—
Jones, B. G.
Kirk, C. D.
Mackie, J.

CHINA

Shanghai—
Doughty, C. J.
Loh, N.-S.
Merritt, C. J.
Portrude, W. M.

Dairen, S. Manchuria
Katsumoto. E.

Tientsin—
Baker, H. W. H.

DENMARK

Copehagen—
Reck, W. E.

Smedegade, Slagelse
Ulrich, K. F.

ENGLAND

East Yorke—
Hill, E. G. T.

Leeds—
Jennins, H. H.

London—
Groom, S. L.
Haden, G. N.
Herring, E.
Nobbs, W. W.
Russell, J. N.

Liverpool—
Honiball, C. R.

Manchester—
Chadwick, J. B.
Yates, W.

Stockport—
Webb, J. W.

Sunderland—
Vaux, N.

Trowbridge—
Haden, W. N.

Westminster—
Barker, A. H.

Winterton—
Cooper, T. R.

Wolverhampton—
Tyson, W. H.

York—
Fryer, F. G.

FRANCE

Paris—
Barre, L. S.
Beaurrienne, A.
Modiano, R.

GERMANY

Dessau—
Junkers, Prof. H.

Stuttgart—
Klein, A.

HOLLAND

Amsterdam—
Hauss, C. F.

IRELAND

Cork—
Barry, P. I.

JAPAN

Tokyo—
Fukui, K.
Kitaura, S.
Saito, Shozo
Sekido, K.
Shinohara, S.
Yamasaki, K.

NEW ZEALAND

Dunedin—
Davies, G. W.

NORWAY

Christiania—
Tjersland, A.

RUSSIA

Leningrad—
Sakouta, M. L.

SOUTH AMERICA

Santiago, Chile—
Carrasco, S.

SWEDEN

Stockholm—
Theorell, H.

SWITZERLAND

Winterthur—
Meier, K.

PAST OFFICERS

AMERICAN SOCIETY *of* HEATING *and* VENTILATING ENGINEERS

1894

President..........Edward P. Bates
1st Vice-President..........Wm. M. Mackay
2nd Vice-President..........Wiltsie F. Wolfe
3rd Vice-President..........Chas. S. Onderdonk
Treasurer..........Judson A. Goodrich
Secretary..........L. H. Hart

Board of Managers

Chairman, Fred P. Smith
Henry Adams
Hugh J. Barron
Edward P. Bates, *Pres.*
A. A. Cary
James A. Harding
L. H. Hart, *Secy.*

Council

Chairman, R. C. Carpenter
Albert A. Cryer
F. W. Foster
Chas. W. Newton
Ulysses G. Scollay, *Secy.*

1895

President..........Stewart A. Jellett
1st Vice-President..........Wm. M. Mackay
2nd Vice-President..........Chas. S. Onderdonk
3rd Vice-President..........D. M. Quay
Treasurer..........Judson A. Goodrich
Secretary..........L. H. Hart

Board of Managers

Chairman, James A. Harding
Geo. B. Cobb
Wm. McMannis
Stewart A. Jellett, *Pres.*
Ulysses G. Scollay
B. F. Stangland
L. H. Hart, *Secy.*

Council

Chairman, R. C. Carpenter
Henry Adams
Edward P. Bates
T. J. Waters
Albert A. Cryer, *Secy.*

1896

President..........R. C. Carpenter
1st Vice-President..........D. M. Quay
2nd Vice-President..........Edward P. Bates
3rd Vice-President..........F. W. Foster
Treasurer..........Judson A. Goodrich
Secretary..........L. H. Hart

Board of Managers

Chairman, Wm. M. Mackay
Hugh J. Barron
W. S. Hadaway, Jr.
R. C. Carpenter, *Pres.*
Stewart A. Jellett
Wiltsie F. Wolfe
L. H. Hart, *Secy.*

Council

Chairman, A. A. Cary
Albert A. Cryer
Wm. McMannis
B. F. Stangland
J. J. Blackmore, *Secy.*

1897

President..........Wm. M. Mackay
1st Vice-President..........H. D. Crane
2nd Vice-President..........Henry Adams
3rd Vice-President..........A. E Kenrick
Treasurer..........Judson A. Goodrich
Secretary..........H. M. Swetland

Board of Managers

Chairman, R. C. Carpenter
Edward P. Bates
W. S. Hadaway, Jr.
Wm. M. Mackay, *Pres.*
Stewart A. Jellett
Wiltsie F. Wolfe
H. M. Swetland, *Secy.*

Council

Chairman, Albert A. Cryer
John A. Fish
Wm. McMannis
James Mackay
B. F. Stangland

1898

President..........Wiltsie F. Wolfe
1st Vice-President..........J. H. Kinealy
2nd Vice-President..........A. E. Kenrick
3rd Vice-President..........John A. Fish
Treasurer..........Judson A. Goodrich
Secretary..........Stewart A. Jellett

Board of Managers

Chairman, Wm. M. Mackay
Thomas Barwick
John A. Connolly
Wiltsie F. Wolfe, *Pres.*
A. C. Mott
Francis A. Williams
Stewart A. Jellett, *Secy.*

Council

Chairman, R. C. Carpenter
Henry Adams
Albert A. Cryer
Wiltsie F. Wolfe, *Pres.*
W. S. Hadaway, Jr.
Wm. McMannis
Stewart A. Jellett, *Secy.*

1899

President..........Henry Adams
1st Vice-President..........D. M. Quay
2nd Vice-President..........A. E. Kenrick
3rd Vice-President..........Francis A. Williams
Treasurer..........Judson A. Goodrich
Secretary..........Wm. M. Mackay

Board of Managers

Chairman, Stewart A. Jellett
B. H. Carpenter
A. A. Cary
Henry Adams, *Pres.*
Wm. Kent
Wiltsie F. Wolfe
Wm. M. Mackay, *Secy.*

Council

Chairman, R. C. Carpenter
John Gormly
W. S. Hadaway, Jr.
Henry Adams, *Pres.*
Wm. McMannis
B. F. Stangland
Wm. M. Mackay, *Secy.*

1900

President..........D. M. Quay
1st Vice-President..........A. E. Kenrick
2nd Vice-President..........Francis A. Williams
Treasurer..........Judson A. Goodrich
Secretary..........Wm. M. Mackay

Board of Governors

Chairman, D. M. Quay
Wm. Kent, *Vice-Chm.*
R. C. Carpenter
John Gormly
D. M. Nesbit
C. B. J. Snyder
Wm. M. Mackay, *Secy.*

1901

President..........J. H. Kinealy
1st Vice-President..........A. E. Kenrick
2nd Vice-President..........Andrew Harvey
Treasurer..........Judson A. Goodrich
Secretary..........Wm. M. Mackay

Board of Governors

Chairman, J. H. Kinealy
Wm. Kent, *Vice-Chm.*
R. C. Carpenter
R. P. Bolton
John Gormly
C. B. J. Snyder
Wm. M. Mackay, *Secy.*

1902

President	A. E. Kenrick
1st Vice-President	Andrew Harvey
2nd Vice-President	Robert C. Clarkson
Treasurer	Judson A. Goodrich
Secretary	Wm. M. Mackay

Board of Governors

Chairman, A. E. Kenrick
John Gormly, *Vice-Chm.*
R. C. Carpenter
Wm. Kent
J. H. Kinealy
C. B. J. Snyder
Wm. M. Mackay, *Secy.*

1903

President	H. D. Crane
1st Vice-President	Wm. Kent
2nd Vice-President	R. P. Bolton
Treasurer	Judson A. Goodrich
Secretary	Wm. M. Mackay

Board of Governors

Chairman, H. D. Crane
C. B. J. Snyder, *Vice-Chm.*
R. C. Carpenter
John Gormly
A. E. Kenrick
Geo. Mehring
Wm. M. Mackay *Secy.*

1904

President	Andrew Harvey
1st Vice-President	John Gormly
2nd Vice-President	Robert C. Clarkson
Treasurer	Ulysses G. Scollay
Secretary	Wm. M. Mackay

Board of Governors

Chairman, Andrew Harvey
John Gormly
Robert C. Clarkson
J. J. Blackmore
R. C. Carpenter
H. D. Crane
A. E. Kenrick
C. B. J. Snyder
Wm. M. Mackay, *Secy.*

1905

President	Wm. Kent
1st Vice-President	R. P. Bolton
2nd Vice-President	C. B. J. Snyder
Treasurer	Ulysses G. Scollay
Secretary	Wm. M. Mackay

Board of Governors

Chairman, Wm. Kent
R. P. Bolton
C. B. J. Snyder
B. H. Carpenter
A. B. Franklin
James Mackay
B. F. Stangland
J. C. F. Trachsel
Wm. M. Mackay, *Secy.*

1906

President	John Gormly
1st Vice-President	C. B. J. Snyder
2nd Vice-President	T. J. Waters
Treasurer	Ulysses G. Scollay
Secretary	Wm. M. Mackay

Board of Governors

Chairman, John Gormly
C. B. J. Snyder, *Vice-Chm.*
R. C. Carpenter
Frank K. Chew
A. B. Franklin
James Mackay
B. F. Stangland
T. J. Waters
Wm. M. Mackay, *Secy.*

1907

President	C. B. J. Snyder
1st Vice-President	James Mackay
2nd Vice-President	Wm. G. Snow
Treasurer	Ulysses G. Scollay
Secretary	Wm. M. Mackay

Board of Governors

Chairman, C. B. J. Snyder
James Mackay, *Vice-Chm.*
R. E. Atkinson
R. C. Carpenter
Edmund F. Capron
Frank K. Chew
A. B. Franklin
Wm. G. Snow
Wm. M. Mackay, *Secy.*

1908

President	James Mackay
1st Vice-President	Jas. D. Hoffman
2nd Vice-President	B. F. Stangland
Treasurer	Ulysses G. Scollay
Secretary	Wm. M. Mackay

Board of Governors

Chairman, James Mackay
Jas. D. Hoffman, *Vice-Chm.*
B. F. Stangland
R. C. Carpenter
Frank K. Chew
John F. Hale
August Kehm
C. B. J. Snyder
Wm. M. Mackay, *Secy.*

1909

President	Wm. G. Snow
1st Vice-President	August Kehm
2nd Vice-President	B. S. Harrison
Treasurer	Ulysses G. Scollay
Secretary	Wm. M. Mackay

Board of Governors

Chairman, Wm. G. Snow
August Kehm, *Vice-Chm.*
John R. Allen
R. C. Carpenter
B. S. Harrison
Samuel R. Lewis
James Mackay
B. F. Stangland
Wm. M. Mackay, *Secy.*

1910

President	Jas. D. Hoffman
1st Vice-President	R. P. Bolton
2nd Vice-President	Samuel R. Lewis
Treasurer	Ulysses G. Scollay
Secretary	Wm. M. Mackay

Board of Governors

Chairman, Jas. D. Hoffman
R. P. Bolton, *Vice-Chm.*
Geo. W. Barr
R. C. Carpenter
Judson A. Goodrich
John F. Hale
Samuel R. Lewis
James Mackay
Wm. M. Mackay, *Secy.*

1911

President	R. P. Bolton
1st Vice-President	John R. Allen
2nd Vice-President	A. B. Franklin
Treasurer	Ulysses G. Scollay
Secretary	Wm. W. Macon

Board of Governors

Chairman, R. P. Bolton
John R. Allen, *Vice-Chm.*
John T. Bradley
R. C. Carpenter
James H. Davis
A. B. Franklin
Jas. D. Hoffman
August Kehm
Wm. W. Macon, *Secy.*

1912

President	John R. Allen
1st Vice-President	John F. Hale
2nd Vice-President	Edmund F. Capron
Treasurer	James A. Donnelly
Secretary	Wm. W. Macon

Board of Governors

Chairman, John R. Allen

John F. Hale, *Vice-Chm.*
Edmund F. Capron
R. P. Bolton
Jas. D. Hoffman
Dwight D. Kimball
Samuel R. Lewis
Wm. M. Mackay
Wm. W. Macon, *Secy.*

1913

President	John F. Hale
1st Vice-President	A. B. Franklin
2nd Vice-President	Edmund F. Capron
Treasurer	James A. Donnelly
Secretary	Edwin A. Scott

Board of Governors

Chairman, John F. Hale

A. B. Franklin, *Vice-Chm.*
John R. Allen
Edmund F. Capron
R. P. Bolton
Frank T. Chapman
Ralph Collamore
James A. Donnelly
Dwight D. Kimball
Wm. W. Macon
James M. Stannard
Theodore Weinshank
Edwin A. Scott, *Secy.*

1914

President	Samuel R. Lewis
1st Vice-President	Edmund F. Capron
2nd Vice-President	Dwight D. Kimball
Treasurer	James A. Donnelly
Secretary	J. J. Blackmore

Council

Chairman, Samuel R. Lewis

E. F. Capron, *Vice-Chm.*
Dwight D. Kimball
John R. Allen
Frank T. Chapman
Frank I. Cooper
James A. Donnelly
John F. Hale
Harry M. Hart
Frank G. McCann
Wm. W. Macon
James M. Stannard
J. J. Blackmore, *Secy.*

1915

President	Dwight D. Kimball
1st Vice-President	Harry M. Hart
2nd Vice-President	Frank T. Chapman
Treasurer	Homer Addams
Secretary	J. J. Blackmore

Council

Chairman, Dwight D. Kimball

Harry M. Hart, *Vice-Chm.*
Homer Addams
Frank T. Chapman
Frank I. Cooper
E. Vernon Hill
Wm. M. Kingsbury
Samuel R. Lewis
Frank G. McCann
J. T. J. Mellon
Henry C. Meyer, Jr.
Arthur K. Ohmes
J. J. Blackmore, *Secy.*

1916

President	Harry M. Hart
1st Vice-President	Frank T. Chapman
2nd Vice-President	Arthur K. Ohmes
Treasurer	Homer Addams
Secretary	Casin W. Obert

Council

Chairman, Harry M. Hart

F. T. Chapman, *Vice-Chm.*
Homer Addams
Charles R. Bishop
Frank I. Cooper
Milton W. Franklin
E. Vernon Hill
Dwight D. Kimball
Henry C. Meyer, Jr.
Arthur K. Ohmes
Fred R. Still
Walter S. Timmis
Casin W. Obert, *Secy.*

1917

President	J. Irvine Lyle
1st Vice-President	Arthur K. Ohmes
2nd Vice-President	Fred R. Still
Treasurer	Homer Addams
Secretary	Casin W. Obert

Council

Chairman, J. Irvine Lyle

A. K. Ohmes, *Vice-Chm.*
Homer Addams
Davis S. Boyden
Bert C. Davis
Milton W. Franklin
Charles A. Fuller
Harry M. Hart
E. Vernon Hill
James M. Stannard
Fred R. Still
Walter S. Timmis
Casin W. Obert, *Secy.*

1918

President	Fred R. Still
1st Vice-President	Walter S. Timmis
2nd Vice-President	E. Vernon Hill
Treasurer	Homer Addams
Secretary	Casin W. Obert

Council

Chairman, Fred R. Still

W. S. Timmis, *Vice-Chm.*
Homer Addams
William H. Driscoll
Howard H. Fielding
H. P. Gant
C. W. Kimball
J. Irvine Lyle
E. Vernon Hill
Frank G. Phegley
Fred. W. Powers
Champlain L. Riley
Casin W. Obert, *Secy.*

1919

President	Walter S. Timmis
1st Vice-President	E. Vernon Hill
2nd Vice-President	Milton W. Franklin
Treasurer	Homer Addams
Secretary	Casin W. Obert

Council

Chairman, Walter S. Timmis

E. Vernon Hill, *Vice-Chm.*
Homer Addams
Howard H. Fielding
Milton W. Franklin
Harry E. Gerrish
George B. Nichols
Frank G. Phegley
Fred. W. Powers
Robt. W. Pryor, Jr.
Champlain L. Riley
Fred R. Still
Casin W. Obert, *Secy.*

1920

President	E. Vernon Hill
1st Vice-President	Champlain L. Riley
2nd Vice-President	Jay R. McColl
Treasurer	Homer Addams
Secretary	Casin W. Obert

Council

Chairman, E. Vernon Hill

C. L. Riley, *Vice-Chm.*
Homer Addams
Jos. A. Cutler
Wm. H. Driscoll
A. C. Edgar
Alfred Kellogg
Jay R. McColl
George B. Nichols
Robt. W. Pryor, Jr
W. S. Timmis
Perry West
Casin W. Obert, *Secy.*

1921

President	Champlain L. Riley
1st Vice-President	Jay R. McColl
2nd Vice-President	H. P. Gant
Treasurer	Homer Addams
Secretary	Casin W. Obert

Council

Chairman, Champlain L. Riley

Jay R. McColl, *Vice-Chm.*
Homer Addams
Jos. A. Cutler
Samuel E. Dibble
Wm. H. Driscoll
H. P. Gant
E. S. Hallett
E. Vernon Hill
Alfred Kellogg
E. E. McNair
Perry West
Casin W. Obert, *Secy.*

1922

President	Jay R. McColl
1st Vice-President	H. P. Gant
2nd Vice-President	Samuel E. Dibble
Treasurer	Homer Addams
Secretary	Casin W. Obert

Council

Chairman, Jay R. McColl

H. P. Gant, *Vice-Chm.*
Homer Addams
Jos. A. Cutler
Samuel E. Dibble
Wm. H. Driscoll
E. S. Hallett
L. A. Harding
E. E. McNair
H. J. Meyer
C. L. Riley
Perry West
Casin W. Obert, *Secy.*

1923

President	H. P. Gant
1st Vice-President	Homer Addams
2nd Vice-President	E. E. McNair
Treasurer	Wm. H. Driscoll
Secretary	C. W. Obert

Council

Chairman, H. P. Gant

Homer Addams, *Vice-Chm.*
W. H. Carrier
J. A. Cutler
S. E. Dibble
Wm. H. Driscoll
E. S. Hallett
Alfred Kellogg
Thornton Lewis
E. E. McNair
Perry West
Casin W. Obert, *Secy.*

1924

President	Homer Addams
1st Vice-President	S. E. Dibble
2nd Vice-President	William H. Driscoll
Treasurer	Perry West
Secretary	F. C. Houghten

Council

Chairman, Homer Addams

S. E. Dibble, *Vice-Chm.*
F. Paul Anderson
W. H. Carrier
J. A. Cutler
William H. Driscoll
H. P. Gant
W. E. Gillham
L. A. Harding
Alfred Kellogg
Thornton Lewis
Perry West
F. C. Houghten, *Secy.*

1925

President	S. E. Dibble
1st Vice-President	Wm. H. Driscoll
2nd Vice-President	F. Paul Anderson
Treasurer	Perry West
Secretary	F. C. Houghten

Council

Chairman, S. E. Dibble

Wm. H. Driscoll, *Vice-Chm.*
Homer Addams
F. Paul Anderson
W. H. Carrier
J. A. Cutler
W. E. Gillham
W. T. Jones
Thornton Lewis
J. H. Walker
Perry West
A. C. Willard
F. C. Houghten, *Secy.*

1926

President	W. H. Driscoll
1st Vice-President	F. Paul Anderson
2nd Vice-President	A. C. Willard
Treasurer	W. E. Gillham
Secretary	A. V. Hutchinson

Council

Chairman, W. H. Driscoll

F. Paul Anderson, *Vice-Chm.*
W. H. Carrier
J. A. Cutler
S. E. Dibble
W. E. Gillham
C. V. Haynes
W. T. Jones
E. B. Langenberg
Thornton Lewis
J. F. McIntire
A. C. Willard

1927

President	F. Paul Anderson
1st Vice-President	A. C. Willard
2nd Vice-President	Thornton Lewis
Treasurer	W. E. Gillham
Secretary	A. V. Hutchinson

Council

Chairman, F. Paul Anderson

A. C. Willard, *Vice-Chm.*
H. H. Angus
W. H. Carrier
W. H. Driscoll
Roswell Farnham
H. H. Fielding
W. E. Gillham
C. V. Haynes
John Howatt
W. T. Jones
J. J. Kissick
E. B. Langenberg
Thornton Lewis
J. F. McIntire
H. Lee Moore
F. B. Rowley

1928

President	A. C. Willard
1st Vice-President	Thornton Lewis
2nd Vice-President	L. A. Harding
Treasurer	W. E. Gillham
Secretary	A. V. Hutchinson

Council

Chairman, A. C. Willard

Thornton Lewis, *Vice-Chm.*
F. Paul Anderson
H. H. Angus
W. H. Carrier
N. W. Downes
Roswell Farnham
C. V. Haynes
John Howatt
W. T. Jones
J. J. Kissick
E. B. Langenberg
J. F. McIntire
H. Lee Moore
F. B. Rowley

1929

President	Thornton Lewis
1st Vice-President	L. A. Harding
2nd Vice-President	W. H. Carrier
Treasurer	W. E. Gillham
Secretary	A. V. Hutchinson
Technical Secretary	P. D. Close

Council

Chairman, Thornton Lewis

L. A. Harding, *Vice-Chm.*
H. H. Angus
W. H. Carrier
N. W. Downes
Roswell Farnham
C. V. Haynes
John Howatt
W. T. Jones
E. B. Langenberg
G. L. Larson
F. C. McIntosh
W. A. Rowe
F. B. Rowley
A. C. Willard

7+7